# A SOURCE BOOK OF REMEDIAL MATERIALS FOR TEACHING BIOLOGY AT HIGHER SECONDARY LEVEL

256

256

Received
Council ... 23/12/12
293
SCERT, West Bengal

**Dr. M.K Satapathy**
**Programme Coordinator**

विद्ययाऽमृतमश्नुते
एन सी ई आर टी
NCERT

**REGIONAL INSTITUTE OF EDUCATION**

(National Council of Educational Research and Training)

**Bhubaneswar 751007**

**1998**

# A SOURCE BOOK OF REMEDIAL MATERIALS FOR TEACHING BIOLOGY AT HIGHER SECONDARY LEVEL

256

Received
Con... 23/12/98
203
SCERT, West Bengal

**Dr. M.K Satapathy**
**Programme Coordinator**

विद्ययाऽमृतमश्नुते

एन सी ई आर टी
NCERT

REGIONAL INSTITUTE OF EDUCATION

(National Council of Educational Research and Training)

Bhubaneswar 751007

1998

# A SOURCE BOOK OF REMEDIAL MATERIALS FOR TEACHING BIOLOGY AT HIGHER SECONDARY LEVEL

**Dr. M.K Satapathy**
**Programme Coordinator**

N.C.E.R.T. W.C. Library
Calcutta
25/3, B.C. Road

REGIONAL INSTITUTE OF EDUCATION

(National Council of Educational Research and Training)

Bhubaneswar 751007

1998

I.C.E.R.T. W.S. LIBRARY
Date 30.7.99
Accn. No. 9899

# FOREWORD

Resource material for Teachers of Senior Secondary level in Biology has been developed by the faculty of this Institute based on the analysis of common errors in Biology committed by students at the +2 Science examination. The resource materials include remedial strategies to transact hard concepts and concept centered teaching-learning.

I am sure the materials would be useful to the teachers for effective transaction of difficult curricular concepts in the classroom. It will also help the authorities of Higher Secondary Council and other educational policy makers in designing need based teacher training programmes for teachers of senior secondary level.

I appreciate the efforts of Dr. M.K. Satpathy, Reader in Botany who acted as the Programme Coordinator for formulating the resource material within prescribed time frame.

**Prof. D.K. Bhattacharjee**
**Principal**

# PREFACE

As a part of RIE's commitment for qualitative improvement of schools education in the states the current programs "Development of Remedial materials in Biology" was designed to help in improving the students performance in +2 Science (Biology) Examination. This is based on the results of our earlier programme Analysis of common errors in Biology committed by students at the +2 Science Examination conducted by CHSE, Orissa" in which curricular concepts where students often commit mistakes were listed out.

In a workshop held from 15th Dec. 97 to 19th Dec. 97, faculty members of Science (Biology) Department along with resource persons coming from different colleges of Orissa (Appendix-I) developed print materials on different areas in a suitable style supplemented with charts, diagrams, examples, illustration etc. Moreover for particular concepts suitable methods were suggested for classroom teaching by the teachers along with model questions. The materials have been divided into nine chapters each chapter carrying a list of concepts.

The materials were further reviewed by experts coming from different areas of Biology and finalised. The present report embodies the finalised developed materials. At the end, approaches to Teaching Biology followed by a list of references have been given for ready use by the teachers.

I express my deep sense of gratitude to Principal, RIE, Bhubaneswar and Director, Higher Education, Orissa Bhubaneswar for their support and encouragement for this work.

I thank Prof. and Head, Dept. of Science; Head, Department of Extension Education, my colleagues in the science (Botany/Zoology) Department, resource persons from different colleges and experts from University Departments who extended all their help and support for this work.

(M.K. Satapathy)

**Reader in Botany**
**&**
**Programme Co-ordinator**

# CONTENTS

| CHAPTER | TITLE | PAGE |
|---|---|---|
| | Foreword | |
| | Preface | |
| I | Introduction | 1 |
| II | Diversities of Plant Life | 2-12 |
| III | Morphology of Angiosperm and Complexities of Plant Life | 13-22 |
| IV | Processes in Plants | 23-33 |
| V | Cell Biology and Genetics | 34-53 |
| VI | Introducing Zoology and Animal Life | 54-68 |
| VII | Physiology and Biochemistry | 69-101 |
| VIII | Environmental Biology | 102-107 |
| IX | Embryology | 108-123 |
| X | Economic Zoology | 124-129 |
| XI | Approaches to Teaching Biology ..few words | 130 |
| XII | References | 131-132 |

APPENDIX :

i) List of Resource Persons

ii) List of Reviewers

# I. INTRODUCTION

Biology occupies a specific position in the higher secondary curriculum. The objective of biology teaching (UNESCO, 1980) is to help students to utilize their knowledge for improving their personal lives. It helps in producing informed citizens for coping with biology related social problems such as population and environmental sanitation. Moreover biology education helps in preparing students for academic pursuits appropriate to their needs and interest.

Evaluation an important component of teaching-learning process is ordinarily considered the same as examination and its results are rarely used in enhancing achievement and developing action for improving future teaching learning process. Under this background in 1997 a workshop "Analysis of common errors in biology committed by students at +2 science Examination conducted by CHSE" was conducted and students committing common errors in conceptual areas was listed. On the basis of this workshop output, presently remedial materials have been developed in a suitable style supplemented with diagrams, charts, illustrations etc. The remedial materials have been put under ten chapters. Towards the end, few words on approaches to biology teaching has been added that can put some light on classroom teaching in biology. A list of references has also been added for ready reference of the classroom teachers.

# II. DIVERSITIES OF PLANT LIFE

## DIFFICULT CONCEPTS

In this chapter, the following difficult concepts have been observed where students often commit errors.

**1) Differentiate between :**

(i) Life history and life cycle.
(ii) Spore and gamete.
(iii) Zygote and Zygospore.
(iv) Zoospore and oospore.
(v) Gametophyte and sporophyte.
(vi) Pathogen and parasite.
(vii) Sporophyll & sporangoiphore.

### * Probable Cause of Error

The error is probably due to lack of clear understanding. The above concepts have not been specifically explained in the texts. Moreover, teachers often do not give adequate emphasis on the concepts while teaching in the classroom. Consequently, it leads to confusion and ambiguity in the minds of the learners.

### * Explanation

**(i) Life history/Life cycle**

Life history of an organism includes a brief description of its occurrence, vegetative structure (external and internal) nutrition and reproduction with suitable diagram.

Life cycle refers to the holistic idea of structure and reproduction of an organism with schematic labelled diagrams (cyclic representation showing the different stages of complete life cycle). This includes two important phases i.e. gametophytic and sporophytic generations which operate in a cyclic manner. The former represents halpoid stage while the latter indicates deploid stage. Two crucial points namely, reduction division and gametic union (fertilization/syngamy) are remarkable. From lower groups to higher groups, elaboration and progressive complexties are found in the sporophytic generation while progressive simplification and reduction in the life span of gametophytic generation are marked.

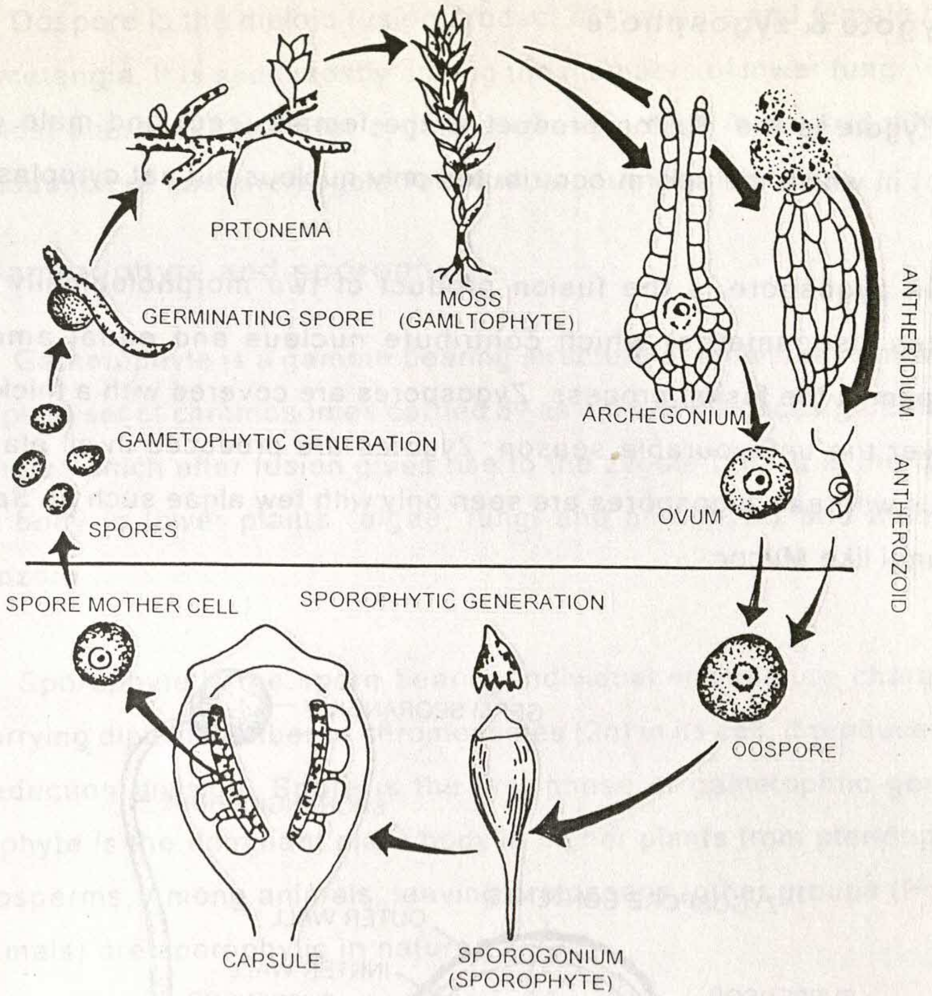


Fig.1. Life cycle of a moss plant showing alternation of generations.

### (ii) Spore and gamete

Spore is an asexual reproductive unit produced from a diploid spore mother cell by reduction division. It is *haploid* and gives rise to gametophyte by direct germination.

Gamete is a sexual reproductive unit produced from the *gametophytic* tissue by mitosis. Gametes are of two types, male and female gamete,. Both are haploid in nature and on fusion produce the zygote which on germination produces the diploid sporphyte. The position and function of spore and gamete can be marked from the life cycle of a moss plant given below. A comparative study of gametophyte and sporophyte will indicate progressive decline and simplification of gametophytes and progressive evolution and complexities in sporophytes.

### (iii) Zygote & zygosphore

Zygote is the fusion product of the female (egg) and male gamete (sperm) in which the sperm contributes only nucleus but not cytoplasm.

In zygospore is the fusion product of two morphologically similar gametes (isogametes) which contribute nucleus and equal amount of cytoplasm in the fusion process. Zygospores are covered with a thick wall to tide over the unfavourable season. Zygotes are produced in all plants and animals whereas zygospores are seen only with few algae such as *Spirogyra* and fungi like *Mucor*.

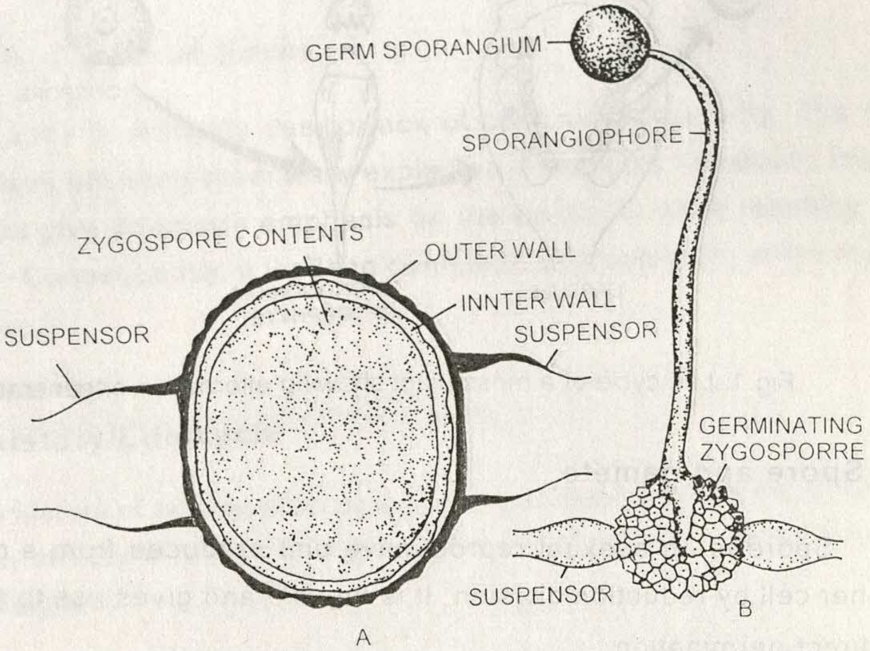


Fig.2. Structure and germination of zygospore in Mucor sp. A.Structural details of zygospore B.Germinating zygospore.

### (iv) Zoospore and oospore

Zoospore is the haploid motile asexual reproductive unit having flagella. It is produced within Zoosporangium and seen mostly with lower algae and fungi. Zoospores may be biflagellate/quadriflagellate/multiflagellats.

Oospore is the diploid fusion product of the male and female gametes or gametangia. It is seen mostly among the members of lower fungi. Oospore is almost alternative term for zygote. However, there is marked differences in production of oospore/zygote found in various plant groups.

### (v) Gametophyte and sporophyte

Gametpphyte is a gamete bearing structure or individual characterised by haploid set of chromosomes carried by its cells. It produces gametes (male & female) which after fusion gives rise to the zygote (2n). It is the dominant plant body in lower plants (algae, fungi and bryophyta) and animals like (protozoa).

Sporophyte is the spore bearing individual or structure characterised by carrying diploid number of chromosomes (2n) in its cell. It produces spores by reduction division. Spore is the first phase of gametophtic generation. Sprophyte is the dominant plant body in higher plants from pteridophytes to angiosperms. Among animals, leaving protozoans, other groups (Porifera to mammals) are sporophytic in nature.

### (vi) Pathogen and parasite

The disease causing agent in living organisms in termed as pathogen. It may be fungi, bacteria, virus etc. All pathogens are parasites.

Examples : *Phytopthora infestans, Ustilago avenae are pathogas.*

Parasites are organisms which survive on living protoplasm of plants and animals. They are heterotrophic organism. All parasites are not pathogens.

### (vii) Sporophyll, sporophore and sporangiophore

Sporophyll is a modified leaf which bears or carries sporangia. It is seen with the members of pteridophytes, (*Selaginella*, *Adiantum* sp., ferns) and Gymnosperms (such as *Cycas*). Sporophore is a stalk that bears spore or seed.

Sporangiophore is a stalk that bears sporangium. It is mostly seen in lower fungi such on *mucor* and species of *Equisetum*.

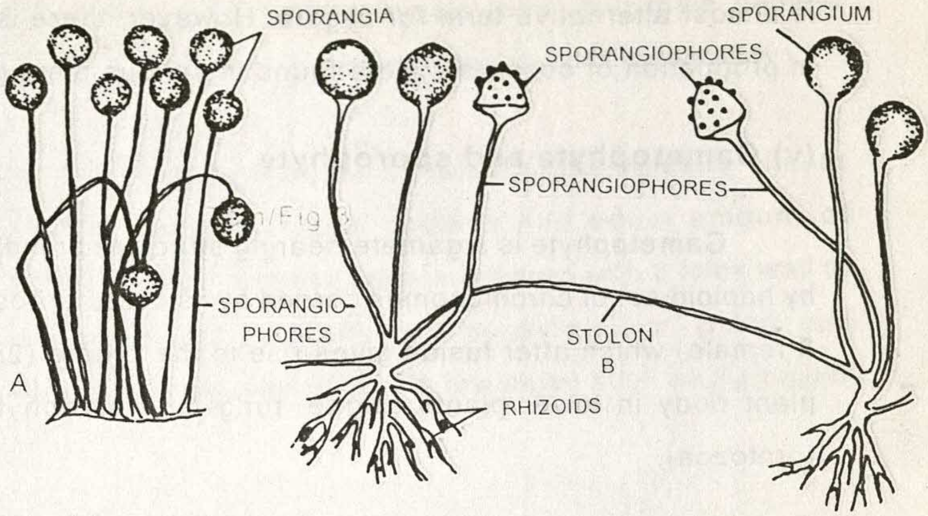


Fig.3.Sporargiophore in mucor.

## (1) Method of teaching

The above discussed concepts can be well taught as and when they come while discussing a particular topic or life cycle. Suitable example and diagram may be given highlighting the hard concept under discussion.

## (2) Discuss following concept(s) :

(i) Alternation of Generation.
(ii) Heterothallism.
(iii) Transfusion tissue
(iv) Types of Lichen.
(v) Naked seeded plant
(vi) Structure of yeast cell.

### (i) Alternation of generation

The life cycle of any organism has two distinct phases or generations; the haploid gametophytic phase and diploid sporophytic phase, both alternating with each other. Fertilization (syngamy) and meiosis (reduction division) are two critical junctures in the life cycle.

Fusion between the gameters (fertilization) brings the end of the gemetophytic phase and there begins the sporophytic phase. Meiosis or reduction division indicates the end of the sporophytic stage.

As we move from lower plants (algae) to higher plants ie (angiospers) there is slowly reduction in the gametophytic generation with expansion of sporophytic phase.

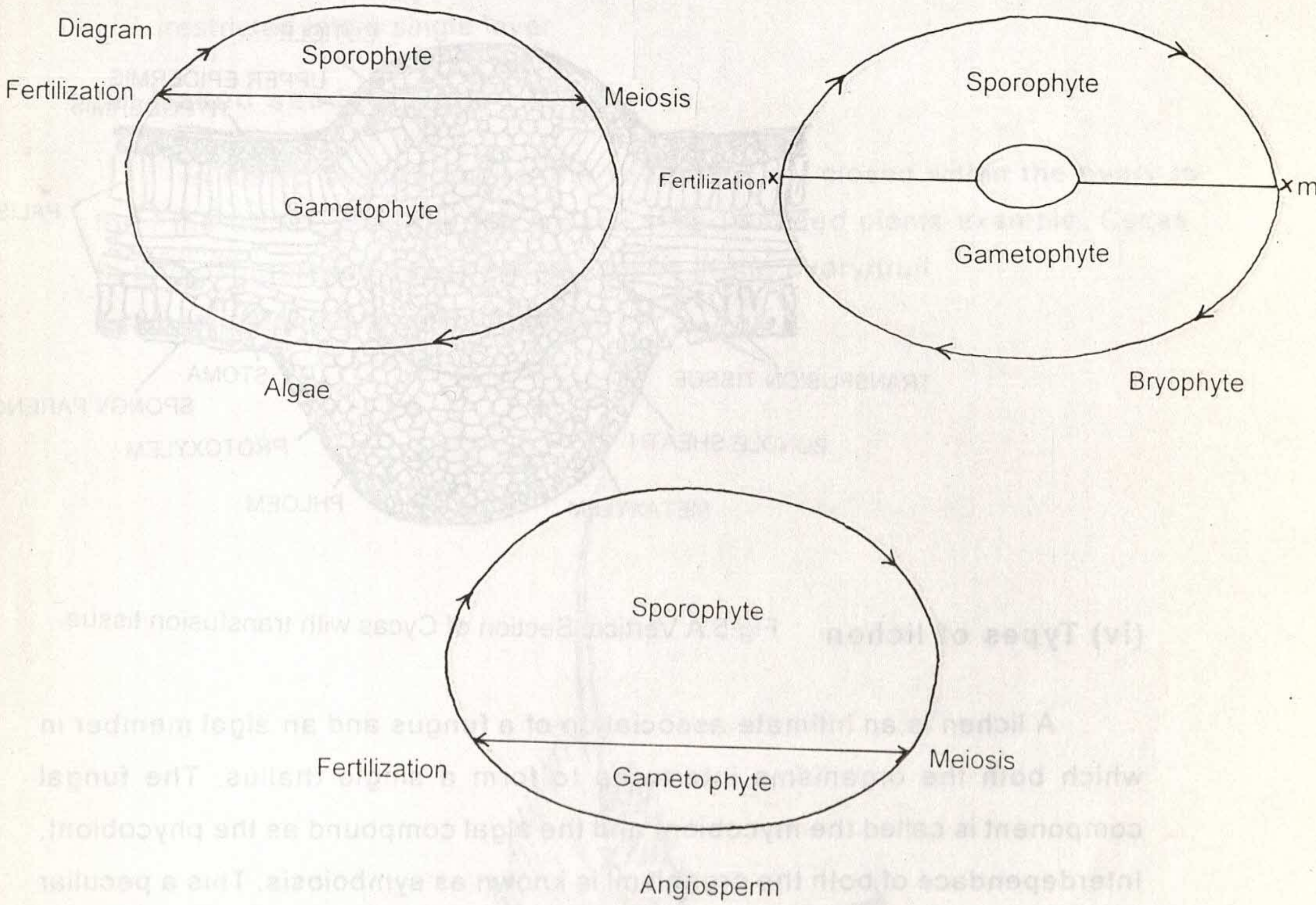


Fig.4. Alternation of generation in different Plant groups.

### (ii) Heterothallism

It is the occurrence of two types of thalli (Note : Thalli is plural, 'Thallus' is singular) (thallus is undifferentiated plant body) which are morphologically similar but physiologically as well as genetically different. The two thalli are indistinguisable but for sexual reproduction, one type fuses with the other. They are designated as + and - strains. The term heterothallism is commonly used for fungi and was first coined by Blakeslee (1904) in connection with zygospore formation in *Mucor*.

### (iii) Transfusion tissue

These are colourless and elongated cells of different sizes found in between the palisade and spongy parenchyma in the leaf of *Cycus*. These cells help in the radial diffusion of water. Presence of transfusion tissue is indicative of xerophytic character mostly found in leaflets of *Cycas* and niddle like leaf of *Pinus*

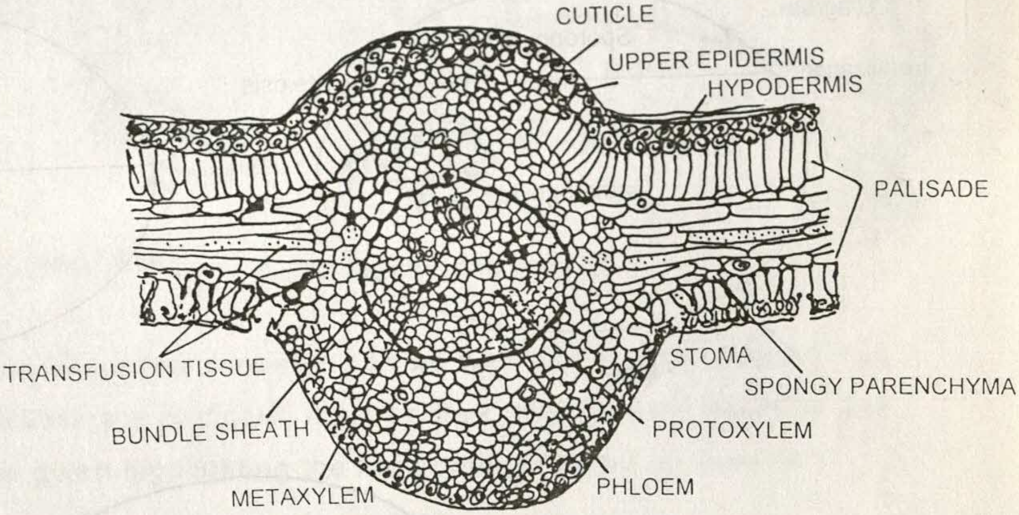


Fig.5.A Vertical Section of Cycas with transfusion tissue.

### (iv) Types of lichen

A lichen is an intimate association of a fungus and an algal member in which both the organisms intertwine to form a single thallus. The fungal component is called the mycobiont and the algal compound as the phycobiont. Interdependace of both the organismi is known as symboiosis. This a peculiar adoptation to thrive in a particular niche and for production as well as utilisation of food.

On the basis of their morphological structure, they have been classified into three types.

(a) Crustose (b) Foliose (c) Fruticose

**Examples :** (a) Crustose - *Graptus, Lecanora*

(b) Foliose - Parmelia, *Physcia*

(c) Fruticose- *Usnea, Ramalina.*

- Basing on the type of fungal member that forms the plant body, that are two types of lichens, ascolichen and basidiolichen. In ascolichen, the fungal partner is a member of ascomycetes where as in basidiolichen, the fungal partner is a member of basidiomycetes.
- Basing on internal structure, the lichers are of two types like homoiomerous and heteromerous. In homoiomerous, the algal cells are uniformly scattered among the enveloping fungal hyphae whereas in others, the algal cells are restricted into a single layer.

### (v) Naked seeded plant

In naked seeded plants, the seeds are not closed within the ovary to form the fruit. Gymnosperms are the naked seeded plants example: Cycas. In angiosperms the seeds are en-closed in the ovary/fruit.

Example : *Mangifera indica* (mango)

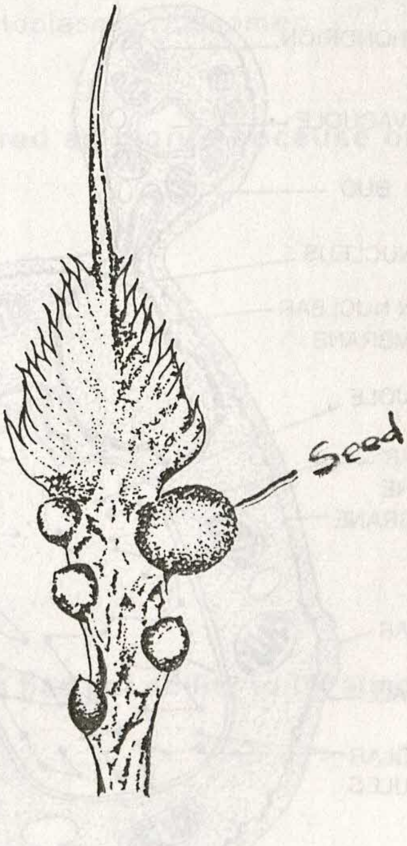


Fig.6.Megasporophylls of Cycas with naked seeds.

### (vi) Structure of yeast

Yeast is an eukargotic, unicellular saprophytic fungus belonging to class Ascomycetes. It is uninucleate surrounded by cell wall made of chitin. It has the cell organellels like centrosome, ribosome and mitochondria.

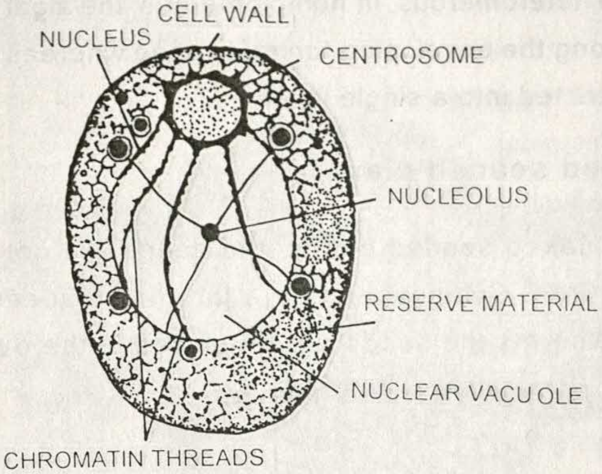


Fig. Diagrammatic representation of parts of a yeast cell.

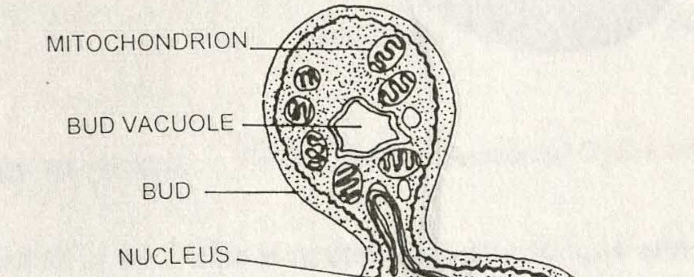


Fig.8.Saccharomyces cerevisia (Sectional view of a budding Yeast cell)

### Method of teaching

The above concepts can be transacted effectively with critical discussion along with diagrams and examples.

## MODEL QUESTIONS

### (i) Choose the most correct answer :

**(1) Viruses are considered as non-living chemical because**

(a) These can be crystallised.
(b) They behave as inhert chemicals outside host.
(c) They don't show any sign of metabolism.
(d) These can be transmitted.

**(2) The prokanyotes differ from eukaryotes in**

(a) The absence of membrane bound organelles.
(b) The presense of naked chromosomes.
(c) The presence of 70s cytoplasmic ribosomes.
(d) All of the above.

**(3) Bacteria are considered as plants because of the presence of**

(a) Small nucleus.
(b) Cell wall.
(c) Plasma membrane.
(d) Spore fermation.

**(4) Palmella stage occurs in**

(a) Spirogyra.
(b) Aspergillus.
(c) Cycas.
(d) Chlamydomonas.

**(5) Which of the followings has got ability to fix atmospheric nitrogen ?**

(a) Some marine red algae.
(b) Some Blue-green algae.
(c) Green algae.
(d) Brown algae.

## Long Questions

1. Draw a neat and labelled diagram of the structure of a bacterial cell. Why it is considered to be a prokayotic organism ?

2. How the bacteria are useful to us in industry and agriculture ?

3. How can we classify the bacteria on the basis of their shape and flagella ?

4. Write short notes :

   (a) Endospore (b) Binary fission (c) Soredia (d) Isidia.

5. What are the chemical nature of viruses ? Which type of nucleic acid do you find with plant viruses ? How does a plant virus differs from an animal virus ?

6. Draw the structure of TMV. How does bacteriophage multiply ?

7. Draw and describe the vegetative structure of spinogyra. What is lateral conjugation ?

8. Write notes (in 5 lines) :

   (a) Scalariform conjugation, (b) Isogamy, (c) Zygospore, (d) Heterothallism.

9. Give the structure of chlorella. How it is useful to us ?

10. Draw the structure of a yeast all. What is halobiontic life cycle ? What are the economical importance of yeast ?

11. Classify Lichens based on their morphology. Mention the economic importance of lichen. How are they useful as pioneers in colonizing rocky habitats ?

12. Give a labelled diagram of the anatomy of Lichen showing the mycobiont & phycobiont.

# III. MORPHOLOGY OF ANGIOSPERMS & COMPLEXITIES OF PLANT LIFE

## DIFFICULT CONCEPTS

### (1) Difference between shoot, stem, branch and twig.

### * Probable causes of the error

(i) The concepts are not adequately explained in the text book.

(ii) The concepts are not correctly explained in the classroom with living materials/ teaching aids like charts or models.

### * Explanation

**Shoot** - Flowering plants consists of an axis with an aerial shoot and root system. Root normally develops from the radicle after the germination of the seed, but may sometimes develop from any other part of the plant body.

**Types**-(a) Taproot: The radicle prolongs directly to from the primary root.

(b) Advantitious root: When roots develop from any other region instead of radicle. But stem develops normally from plumule.

**Stem** - It is the main axis of the aerial system. It usually comprises of branches and leaves. Stems are different from roots in their form, position, structure and function.

**Branch** - It is the lateral appendage of the stem. There are different types of branching.

**Twig** - It is a small portion of a branch.

### 2) Verticillaster inflorescence

In verticillaster type of inflorescence typical of plants with opposite leaves, a cyme arises in each leaf axil. The first axis ends in a flower. Two branches arise below it laterally bearing branches in an alternatively manner.

As flowers are subsessile they appear as a cluster around the nodes, for example. (*Leucas aspera*). Usually this type of inflorescence is found among the members of Lamiaceae (o≡ Labiatae) family.

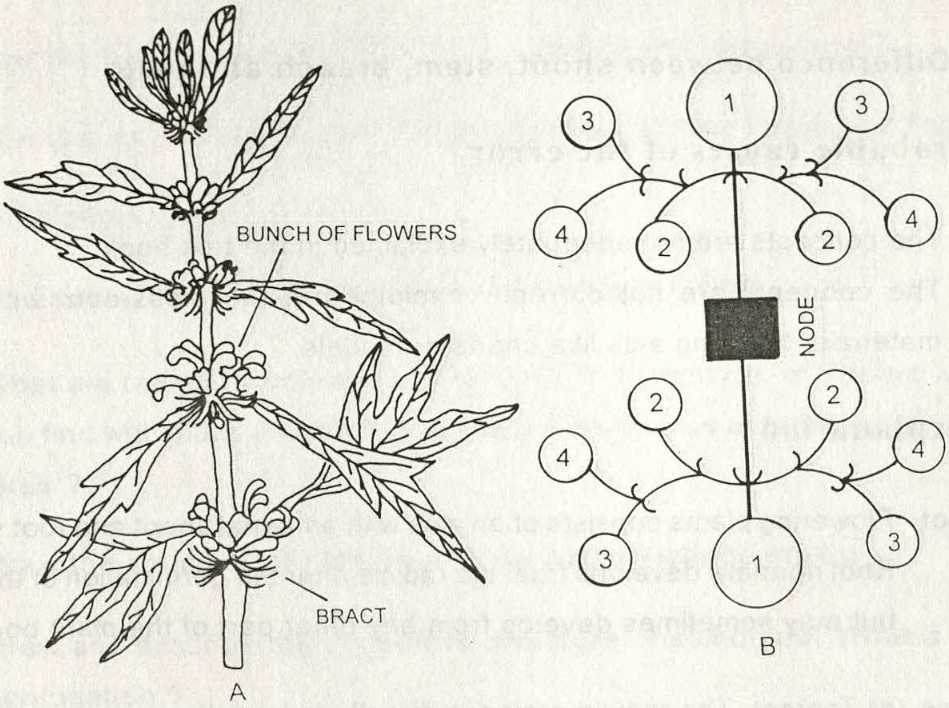


Fig.9 .Verticullaster A. As seen in Leonurus
B.Plan arrangement of flowers in a verticillaster (Top view)

In *Ocimum* the inflorescence axis (peduncle) grows indefinitely bearing flowers in acropetalous order, typical of racemose inflorescence. But at each node the inflorescence pattern is of verticillaster type. So it is more a mixed type of racemose and verticillaster inflorescence called as 'Thyrus' type.

## 3) Understanding about abaxial, adaxial or ventral/dorsal side of leaf

### * Probable Cause of Error/difficulty

(i) The concepts are not clearly explained by the teacher.

### * Explanation

The leaf surface which is continuous with the surface of the part of the stem located above the leaf insertion is designated as the upper, ventral or the adoxial side of the leaf. On the other hand, opposite side of it is termed as the lower, dorsal or abaxial side. In a dorsiventral leaf (cf.dicotmembers) two surfaces are distinct as such upper part receives the sun's ray usually shinning, deep green while lower surface less shinning and less green Isobilateral leaf (cf monocots): Two surfaces are equally illuminated by the sun's ray and distribution of stomata on both surfaces is almost equal.

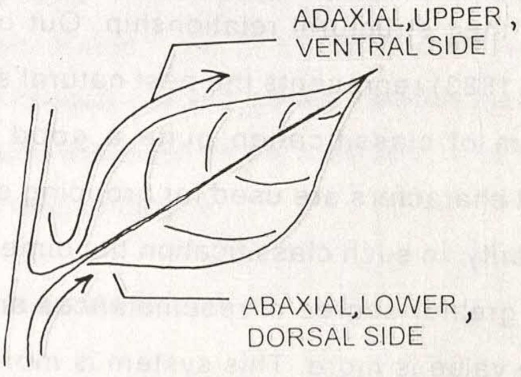


Fig.10.Abaxial and adaxial surfaces of a leaf

## 4) Artificial, Natural and phylogenetic systems of classification.

### * Probable causes of error

(i) The concepts are not clearly explained in the text-book

(ii) The teachers should give adequate stress on the concepts regarding the term classification by citing examples from nonbotanical classification like arrangement of books in a library, arrangement of various types of items in a shop. Then criteria of botanical classification should be explained. Artificial type of classification: In this type of classfication only one/two Criteria (morphological characters) are taken to put the plants in various groups. Consequently, degree of resemblances among the groups is less. But it is easy to recognise the groups

**Example** : Linnaeus classification

## Explanation

### (b) Natural system

Natural system is based upon well defined reproductive and morphological characters and recognises the importances of characters like structure of thalamus, calyx, corolla, cohesion and adhession of floral members and their structural relationship. Out of many, Bentham Hooker's system (1862-1883) represents the best natural system of classification. In a natural system of classification quite a good number of axomorphic or morphological characters are used for grouping of plants mostly on the basis of gross similarity. In such classification the dimention of the group is smaller but there lies greater degree of resemblances among the groups and hence the predictive value is more. This system is more or less academic oriented and Bentham Hookers classifictory system is mostly adopted in arrangement of families of Angiosperms in major Herberia

### Phylogenetic system

Phylogenetic system is a modification of natural system which is principally based on theories of decent and evolution. These systems came into practice during post-Darwinian era where attempts are made to establish genetic and ancestral relationship of plants. In this system of classification mostly endomorphic characters like anatomical, palynological, embryological etc are adopted to categorise the plant groups. Such classifications were presented by Engler and Prantl (1887-1899), Bessey (1893-1915), Hutchinson (1926-1934, and 1959-1973) and others. In true sense of term Hutchinson's classificatory system is not a phylogenetic one since he has not utilised all the above said criteria. Takhtajan's system of classification is truly phylogenetic one.

**Engler and Prantl system (1889-1897)**

In this system the plant kingdom is divided into the major divisions. The 14th being the Embryophyta syphanogama is further divided into 2 sub-divisions - Gymnospermae and Angiospermae. Gymnospermae consist of 7 classes and Anglospermac 2 classes - Monocotyledoneae and Dicoteyledonae. The Monocotyledoneae is further divided into 10 series and the later into 2 sub-classes - Archichlamydeae and Metachlamydeae. Archichlamydeae is further divided into 33 series and Metachlamydeae into 11 series which are again divided into sub-series, families, genus and species. This system of classification has been amply modified by. H. melchoir in 1964 to make it more phylogenetic in nature.

## (5) Classification of meristem

### * Probable cause of the error

(i) Inadequately explained in the text book.

(ii) Transaction of concept by the teacher is not very clear,

### * Explanation

Concepts of meristem: It is embryonic tissue the cells of which continue to divide as a result new cells are continuously added to plant organs like stem and root. Classification according to :

(i) method of devlopment

(ii) according to origin

(iii) position in the plant body

(iv) according to their functions

Meristems may be classified on the absis of growth, plane of division, development, position, and function as given below

**Table .1 Classification of meristermatic tissue**

| Basis of classification | Type of meristem | Examples |
|---|---|---|
| I. Growth | Promeristem<br>derivatives. | Apical initial cell and |
| II. Plane of division | (a) Mass meristem | Young embroyo, |
| | (b) Rib meristem | Endosperm, Epidermus<br>& cartex of root & stem. |
| | (c) Plate meristem | Flat angiospermic leaf ? |
| III. Development | (a) Primery meristem | Apices of stem, root<br>and leaf primordia. |
| | (b) Secondary meristem | Parts of vascular<br>cambium, cork cambium. |
| IV. Position | (a) Apical meristem | Root, stem apex |
| | (b) Lateral meristem | Vascular cambium, cork<br>cambium |
| | (c) Intercalary meristem | Bases of internodes,<br>leaves of grasses,<br>peduncle, gynophore |
| V. Function | (a) Protoderm | Formation of epidermis. |
| | (b) Procambium | Formation of primary<br>vascular tissue. |
| | (c) Ground meristem | Formation of cortex,<br>meristem, pith. |

**(6) Meristomatic behaviour of parenchyma**

*** Probable causes of the error/ difficulty**

Concept is not well explained in the text book.

## Explanation

Parenclyma though a permanent tissue always retains its meristematic character and is therefore a potential meristematic tissue. Parenchyma becomes meristematic during wound healing, formation of adventitions roots, grafting etc. In the regions of medullary rays (in between adjacent vascular bundles) and outer cartex parenchymatous tissues rearrange themselves and revive their meristematic activities forming intefascicular cambium and cork cambium respectively.

## (7) Concept about protoxylem, metaxylem, centripetal, centrifugal arrangements, exach, endarch.

## Probable cause of the error/difficulty

(i) Transaction of the concept is not clear.

(ii) The above concepts are not explained with diagrams in text books.

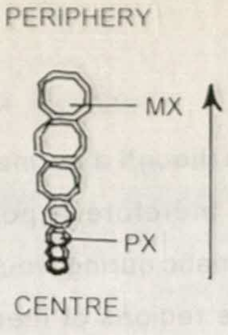
### (i) Protoxylem and metaxylom

The first formed trachearyxylem elements are called protoxylem and laterformed ares are called metaxylem. Protoxylem elements show annular or spiral wall thickenings (lignin depositions) whereas metaxylem elements show scalariform and reticulate thickenings.

Tracheary elements develop from the cambium and the following 3 types of developments are seen

### (i) Centrifugal/ Endarch

The first formed and small sized protoxylem elements develop near the centre of axis and large sized metaxylum elements are developed progressively away from centre. This developmental pattern is called centrifugal. As the protoxylem is situated close to the centre of the axis. The condition is known as endarch.

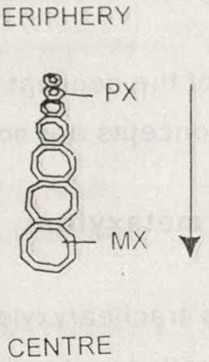


[ Centrifugal / Endarch ]

Fig.11.Endarch Xylem

### (ii) Centripetal/ Exarch

In centripetal type the first formed (protoxylem) elements develop in the region away from the centre of the axis and later formed metaxylem elements develop progressively towards centre of the axis the condition is known as exarch. For eg. Root of seed plants.



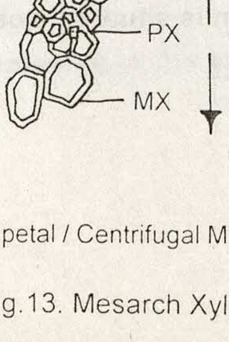
[ Centripetal / Exarch ]

Fig.12. Exarch Xylem

### (iii) Mesarch

Two patches of metaxylem elements are present in a vascular bundles as such protoxylem inbetween two patches of metaxylem.

**Examples :** Vascular bundles in the rachis of *cycas*



Centripetal / Centrifugal Mesarch

Fig.13. Mesarch Xylen

# MODEL QUESTIONS

## A) Short Questions

Fill in the blanks choosing appropriate word from the bracket.

1. Wood is commonly composed of ________________________________.
   (cambium, pholem, vascular bundle, secondary xylem)

2. Companion cells are associated with ____________________________
   (Collenchyma, secondary cambium, sievetubes, meduallacy parenchyama).

3. Plants increase in lenght due to the activitiy of ____________________
   (Vasucular ambium, apical meristems, cork cambium)

4. Annual rings are distinct in plants growing in ______________ regions.
   (Tropical, arctic, grasland, temporate).

5. Give diagramatic representation of the following
   (i) Bicollateral vascular bundle.
   (ii) Centripetal xylem
   (iii) Longitudinal section of hydathode.
   (iv) Monadelphous and monothecous condition.

## B. Short answer type

1. Distinguish between

   a) Tracheid and vessel
   b) Laticiferous and glandular tissue ?
   c) Heart wood and sapwood.
   d) Fascicular and interfascicular cambium
   e) Stem tuber and root tuber
   f) Root and Rhizoid
   g) Cladode and phyllode

S.C.E.R.T. W.B. LIBRARY
Date 30.7.99
Acc. No 9899

## C. Give reasons in three sentences

a) Some plants grow on smooth surface of a wall.

b) A huge banyan tree bears the heavy weight of its conopy.

c) In fig the flowers are present inside a fruit like fleshy thalamus.

d) We find motor cells at the epidermal region of some xerophytic grasses.

e) Injured epideimal portion in plants get healed in due course.

## D. Identify the the important part/ product

a) When we decapitate a yound *calotrotpis* twig a whitish liquid comes out.

b) A log of sal wood has dark brown colored central area.

c) Plant materials used for stopper/caps in glass bottles.

d) Honey collected by honey-bee is obtained from a perticular part of the flower.

## E. Long questions

1. What is meristem ? Where the meristemic tissues are located in plants ? What are their functions ?

2. How secondary thickining is accomplished in of angiospermic stem ? What is its significance ?

3. What is the need for plant classification ? What are the different systems of classifications ? Enumerate the principles on which the plant classificatory systems are based.

4. Which family provides the cereals ? Describe the floral characters of this family with general floral diagram and floral formula. Write down the botanical names of 3 economically important plants belonging to this family.

# IV. PROCESSES IN PLANTS

## DIFFICULT CONCEPTS

1. Seed Dormancy
2. Phases of Germination

### * Probable causes of error

(i) The concepts are not well explained in common +2 Text Books

(ii) Extent to be covered by the teacher is not clear.

(iii) Difficulties in transacting the concept in the classroom

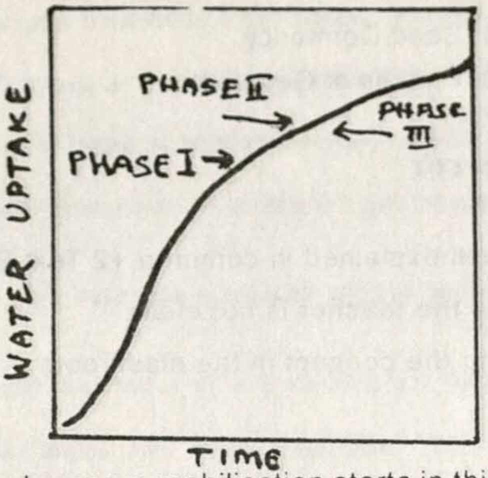
### * Explanation

### 1. Seed Dormancy

Viable seeds sometimes do not readily germinate even when the favourable external if the necessary environmental conditions (such as water, temperature, air and light) necessary for germination are available. Such seeds are said to be in a dormant condition. The dormancy of a seed is caused by the presence of inhibitory factors in the seed coat or in the embryo. The period of dormancy is different for the seeds of different plants. Seed germinates only when the inhibitory factors are removed. In natural condition the dormancy is found to break after the specified period of dormancy of the seed. One can also break dormancy of the seed by artificial means. This is called the breaking of dormancy.

### 2. Phases of Germination

Morphologically seed germination is the transformation of embryo of a seed into a seedling. Protrusion of radicle from a seed is marked as the germination of seed. Physiologically the entire process of germination is separated into three phases. The first phase is the adsorption of water by seed known as imbibition. This is followed by a phase with negligible water uptake called as activation phase. The last phase again with increased water uptake is identified with protrusion of radicle. This last phase is also called as the emergence phase.



The seed reserve mobilisation starts in this last phase in which reserves like fats, proteins and carbohydrates are degraded/converted as to the substrates of respiration.

### 3. Mechanism of stomatal movement

### * Probable causes of error

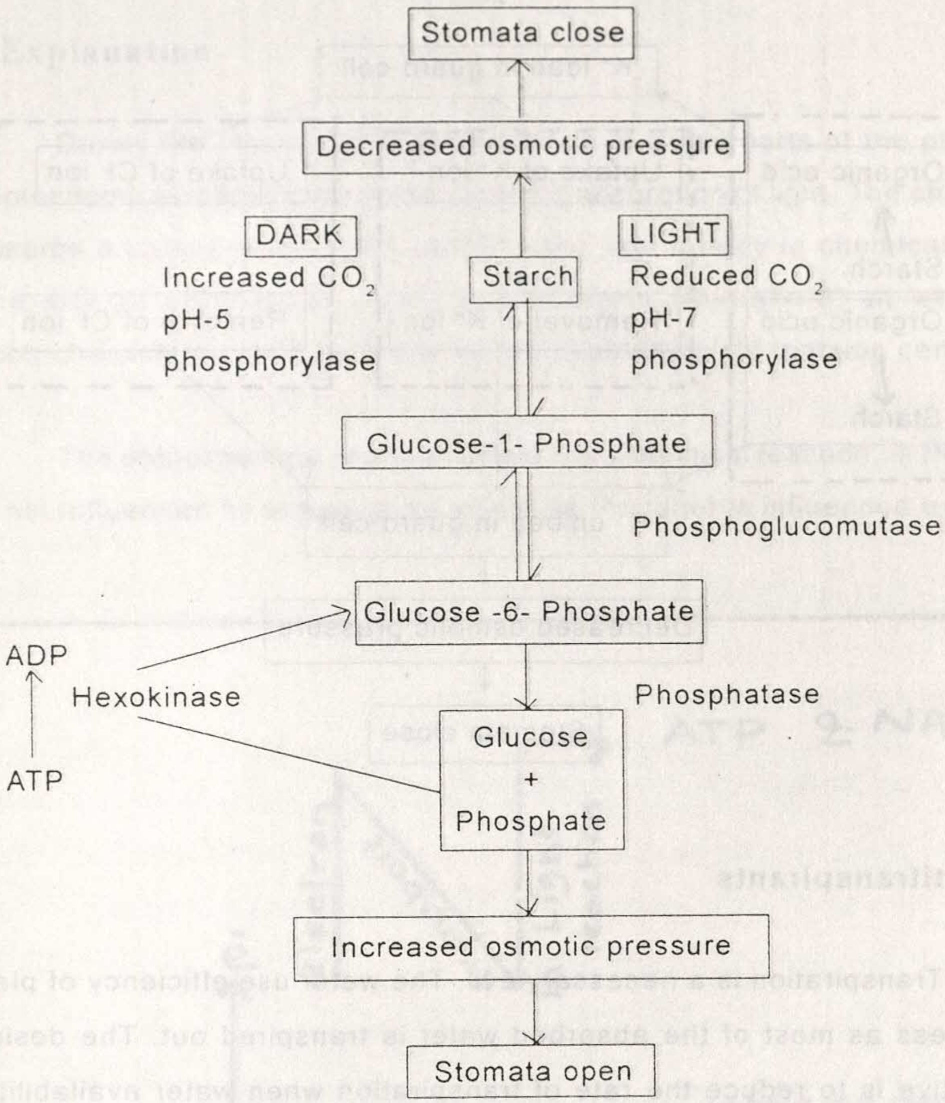
i. Inadequate and confusing information available in the prescribed text books
ii. Difficult in transacting the concept

### * Explanation

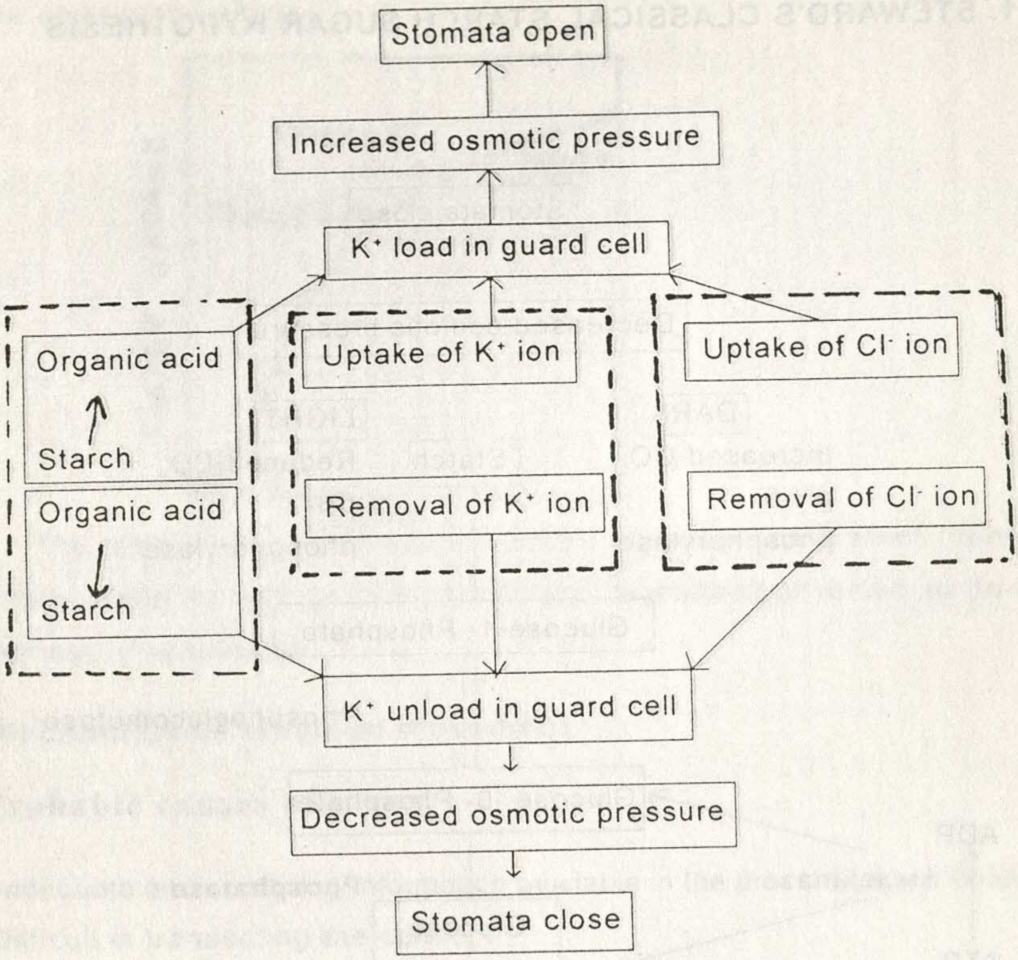
Generally transpiration is regulated by stomata movement. The guard cells are responsible for opening and closing of stomata. Stomata open when guard cells become turgid by rapid uptake of water. This happens because of the increase in the osmotic pressure of guard cell protoplant. Stomatal opening is possible only when the osmotic pressure of guard cell is more than that of subsidiary cells. The suitable hypotheses[3] considered for explaining the regulation of osmotic pressure of guard cells, and therefore, for the opening and closing of stomata are :-

a) Steward's Classical Starch sugar hypotheses
b) Active K+ transport theory

## 1. STEWARD'S CLASSICAL STARCH SUGAR HYPOTHESIS



## 2. ACTIVE $K^+$ TRANSPORT THEORY



## 4. Antitranspirants

Transpiration is a necessary evil. The water use efficiency of plant is very less as most of the absorbed water is transpired out. The desirable objective is to reduce the rate of transpiration when water availability for the plants are limited. Any material applied to plant foliage to reduce water loss by transpiration is called antitranspirants. Anti-transpirant should be such that it should check the water diffusion without affecting the permeability of $CO_2$ and $O_2$. Phenlymercuricacetate, silicone oils and waxy materials are generally used as antitranspirants. Antitranspirant enhance the productivity of crop.

5. Photochemical reaction

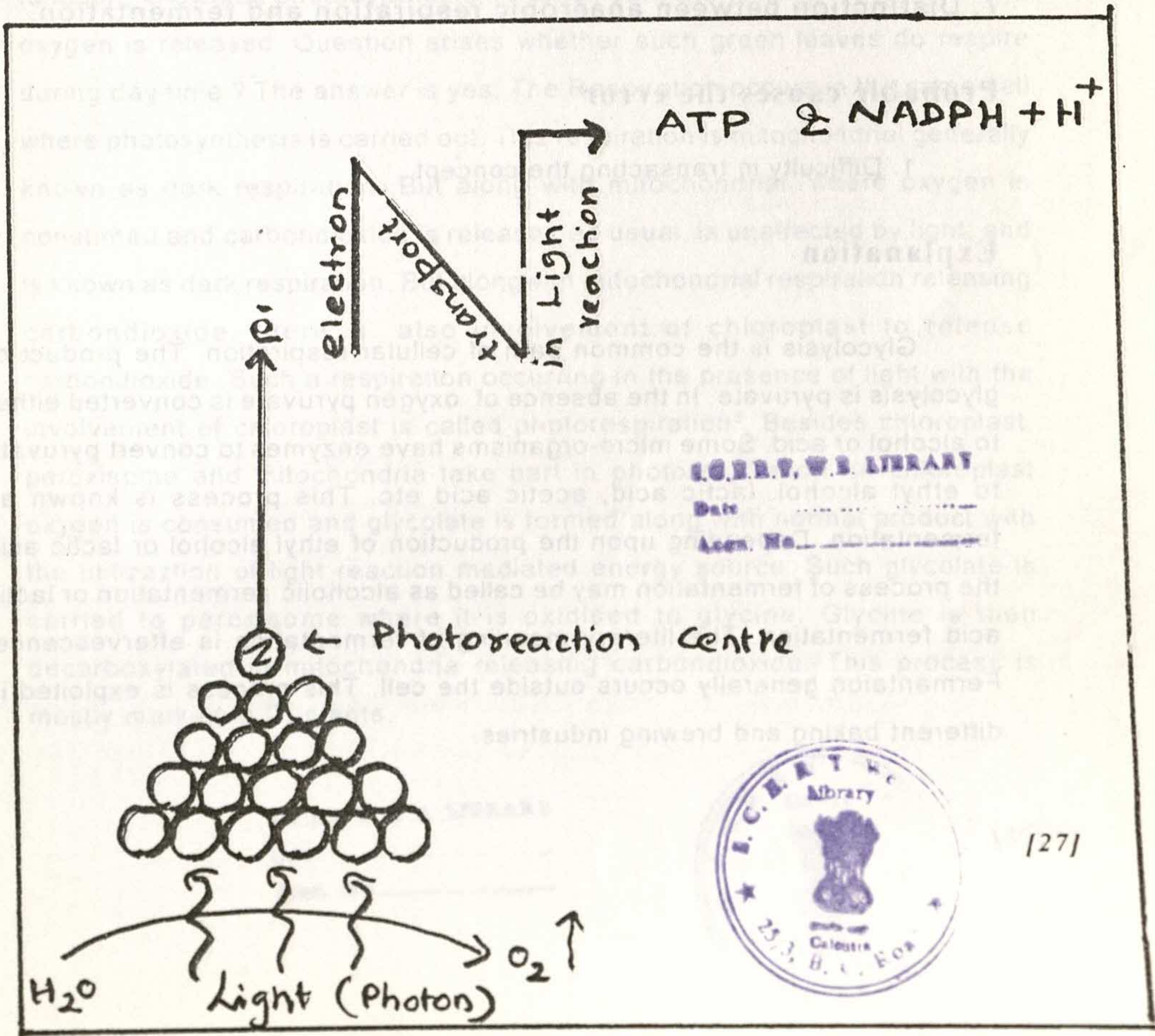
## * Probable causes of the error

i. Difficulty in transacting the concept
ii. Difficulty in students understanding of the concepts.

## * Explanation

During the process of photosynthesis in green parts of the plants the photochemical reaction is initiated with the absorption of light. The chlorophyll absorbs a photon of light and converts the light energy to chemical energy. The site of chlorophyll bearing membrane (thyllakoid) at which the photochemical reaction occurs is called photochemical reaction centre.

The photochemical reaction differs from chemical reaction as the former is not influenced by temperature where as the latter is influenced by it.



S.C.E.R.T., W.B. LIBRARY
Date
Accn. No.

## 6. Source of Oxygen in Photosynthesis

The substrates of photosynthesis are water and carbodioxide. The products of the process are carbohydrate and oxygen.

$$CO_2 + H_2O \longrightarrow C_6H_{12}O_6\Uparrow$$

Here the question arises whether the oxygen evolved during photosynthesis comes from water or cabondioxide. It was Robin Hill (1940) who demonstrated that a suspension of Spinach chlorplasts in water when illuminated in the presence of a hydrogen acceptor like potassium ferricyanide would released oxygen in the absence of carbon dioxide. So obviously the oxygen comes from water and not from carbon dioxide. This reaction is commonly known as Hill reaction. The light-driven splitting of water to produce oxygen is called photolysis of water. Using water having radioactive isotope of oxygen ($O^{18}$) it was confirmed that in photosynthesis oxygen is released from water.

## 7. Distinction between anaerobic respiration and fermentation.

### Probable causes the error

1. Difficulty in transacting the concept

### Explanation

Glycolysis is the common path of cellular respiration. The product of glycolysis is pyruvate. In the absence of oxygen pyruvate is converted either to alcohol or acid. Some micro-organisms have enzymes to convert pyruvate to ethyl alcohol. lactic acid, acetic acid etc. This process is known as fermentation. Depending upon the production of ethyl alcohol or lactic acid the process of fermentation may be called as alcoholic fermentation or lactic acid fermentation. The literary meaning of fermentation is effervescence. Fermantaion generally occurs outside the cell. This process is exploited in different baking and brewing industries.

In anaerobic respiration the pyruvate is reduced to lactate as in human skeletal muscle under the oxygen stress. In this case the product of glycolysis i.e. pyruvate is converted to lactate continuously releasing more amount of energy. Anaerobic respiration is also marked in just germinating seeds which follows a separate pathway other than glycolysis.

## 8. Photorespiration

### * Probable cause of the error

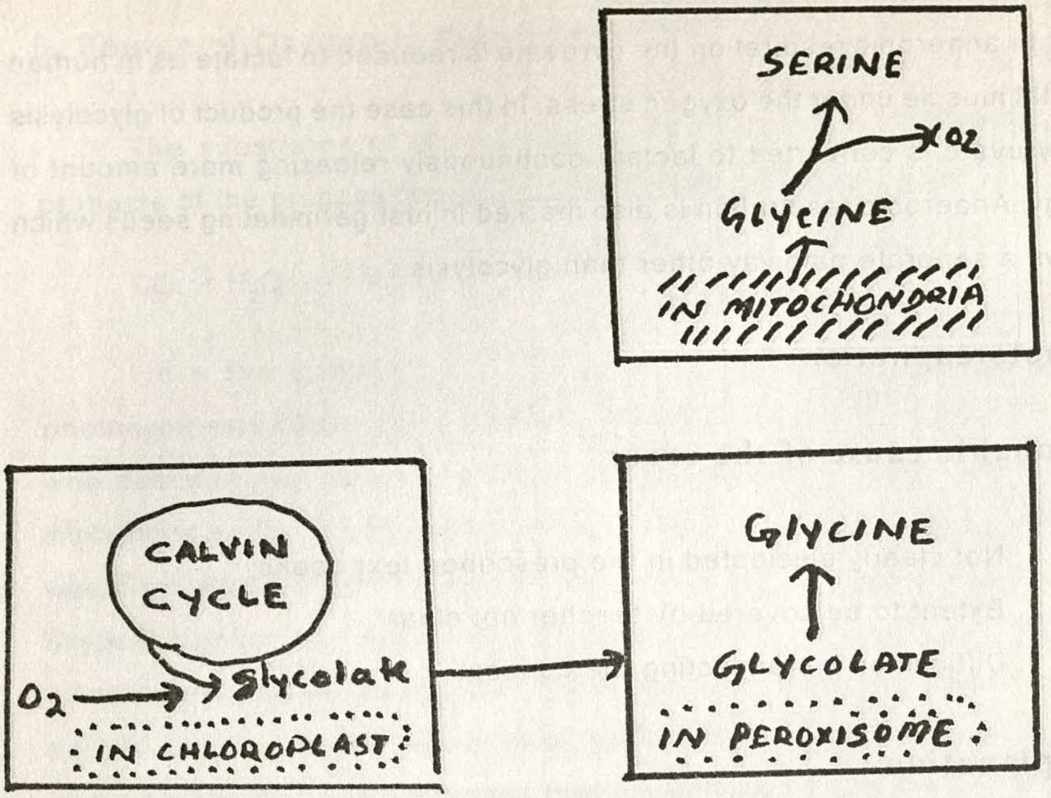
1. Not clearly elucidated in the prescribed text books.
2. Extent to be covered by teacher not clear
3. Difficulties in transacting the concept

### * Explanation

Plants produce food during day time. The green leaves carry out the function, known as photosynthesis, in which carbondioxide is consumed and oxygen is released. Question arises whether such green leaves do respire during day time ? The answer is yes. The Respiration occurs in the same cell where photosynthesis is carried out. This respiration is mitochondrial generally known as dark respiration. But along with mitochondrial, where oxygen is consumed and carbondioxide is released as usual, is unaffected by light, and is known as dark respiration. But alongwith mitochondrial respiration releasing carbondioxide, there is also involvement of chloroplast to release carbondioxide. Such a respiration occurring in the presence of light with the involvement of chloroplast is called photorespiration[3]. Besides chloroplast, peroxisome and mitochondria take part in photorespiration. In chloroplast oxygen is consumed and glycolate is formed along with normal product with the utilizaztion of light reaction mediated energy source. Such glycolate is carried to peroxisome where it is oxidised to glycine. Glycine is then decarboxylated in mitochondria releasing carbondioxide. This process is mostly marked in $C_3$ plants.

S.C.E.R.T., W.B. LIBRARY
Date ........................
Accn. No.........................

S.C.E.R.T.
Library
Calcutta
25/3, B. C. Roy



9. Distinction between hormones and enzymes

### * Probable causes of the error

1. Difficulties in transacting the concept
2. Concept is inadequately explained in text books.

### * Explanation

Living organisms manifest different characters. Such characters are the direct or indirect result of different chemical reactions carried out in the cell. These reactions in the cell are mediated, controlled and excited by different biomolecules. Two such important groups of biomolecules are enzymes and hormones. The enzymes are proteins catlysing the cellular chemical reactions. The hormones known as "Chemical messengers" are either peptides, amines or steroids which excite special cellular reactions. The enzymes are generally synthesized in the same cell where they take part in the reaction. The site of synthesis and action of hormones are different. The amount of hormones needed to tiger or excite a reaction is much less or rather trace in comparison to enzymes. Sensitivity of enzymes to change in temperature is much more than hormones.

### Method of Teaching

The difficult concepts discussed above can well be taught through discussion and experiments wherever possible. The teacher should be critical in his approach and specific while citing examples during teaching as the students need clear understanding in the area. Activities may be conducted wherever possible.

## MODEL QUESTIONS

### 1. Fill up the blanks

i. Solute content of a solution determines the ______________ pressure of an osmotic system.

ii. Plants exposed to intermittent light show ____________________ rate of photosynthesis than those exposed to continuous light.

iii. Kidney shaped cells around the stomatal pore are called _________ cells.

iv. The first stable product in dark reaction of photosynthesis is ____________.

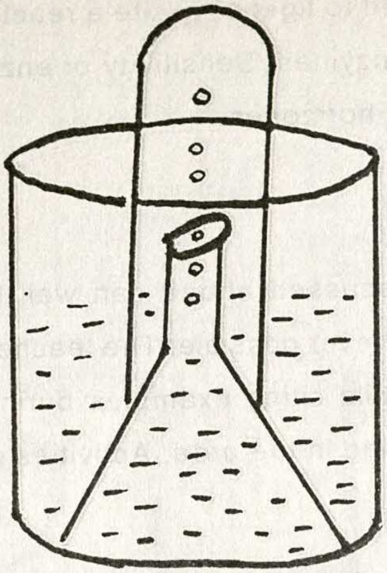
v. Determination of ______________________ pressure is required for good preservation of storage potatoes.

vi. In the field, to increase water use efficiency of crop plants ____________ can be sprayed.

vii. Stomata ← Starch pH ___?___ → Osmotically Stomata close in guard cell
__________\ active sugar → open __________-in guard cell pH ← ___?___

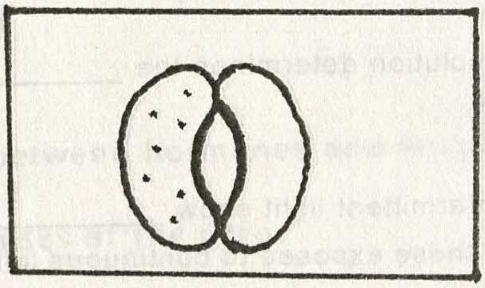
**(Fill up the blank against pH with high & low)**

ix. Diagram/6cm



(Fill in the missing portion of the diagram)

x. Diagram/5cm



(Draw the lacking portion of the diagram)

**2. Distinguish between**

a. Light reaction & Dark reaction
b. Dark respiration & photorespiration
c. Hormone & Enzyme
d. Absorption and imbibition

## Long Questions

1. Photosynthesis involves the removal of electron from chlorophyll; splitting of water; and production of ATP and reduced conzymes. Explain concisely how these processes are linked.

2. Explain one of the theories you feel suitable for control of stomatal movement.

3. Experimentally prove the tissue involved in translocation of water. Discuss the role of transpiration pull in ascent of cell sap

4. What are the cellular components taking part in protein synthesis. Discuss the structure and functions in 5 sentences. Illustrate the process of translation.

5. Schematically draw the different steps involved in the process common to aerobic and anaerobic respiration. How micro organisms convert the end product of this process causing effervescence.

# V. CELL BIOLOGY AND GENETICS

## DIFFERENT CONCEPTS

### 1. Cell shape

### * Probable Cause of Error/Difficulty

(i) Two dimensional structure is built in students mind.

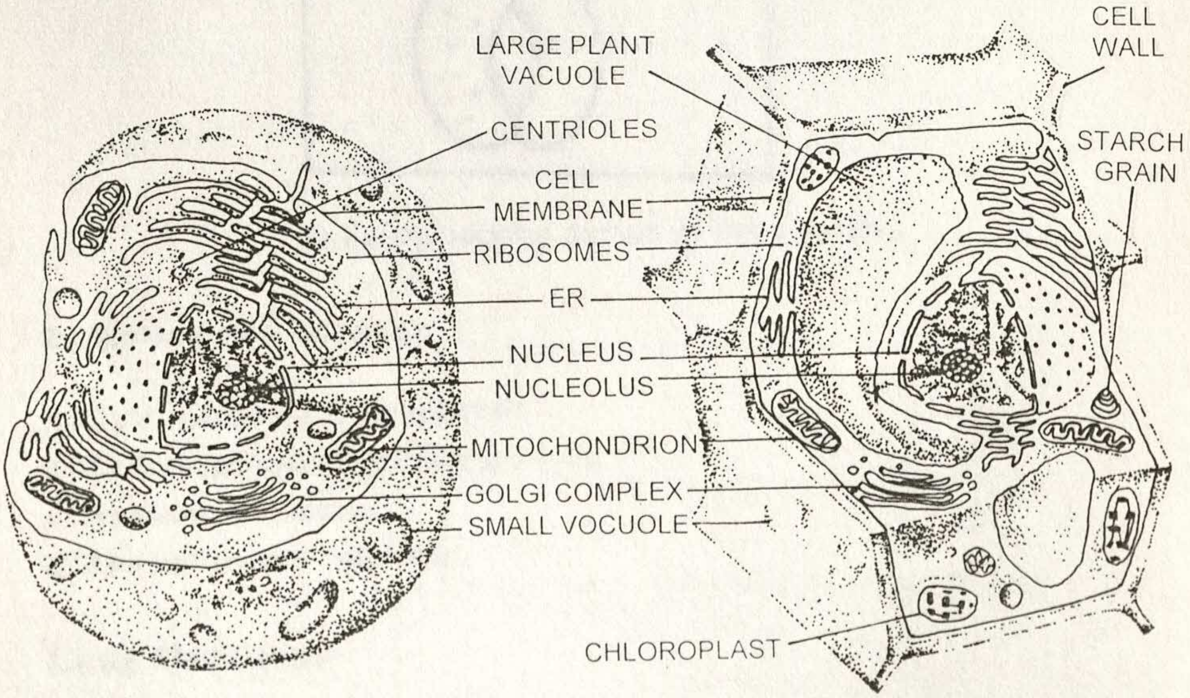
(ii) The arrangement and position of different cellular components are not clearly understood by the students.

(iii) Students usually misconceive yolk of hens egg as the nucleus of the cell in an egg.

(iv) Lack of complete and clearcut explanation in the text.

### * Explanation

A cell is always three dimensional. A suitable diagram of a cell can develop the three dimensional concept in students mind.



ANIMAL CELL

PLANT CELL

Fig.14. Diagrammatic representation of (A) Animal and (B) Plant Cell

While explaining the structure of the hen's egg as a model of a cell, the concept be carefully explained. It should be mentioned that the yolk is never the nucleus of the egg.

## 2. Concept of Protoplast, Protoplasm and Cytoplasm

### Explanation

Protoplast (content of the cell exclusive of the cell wall)

**A. Cytoplasm (cytoplasm + nucleoplasm = protoplasm). It includes :**

a) Plasma membrane
b) Vacuelar membrane
c) Microtubules
d) Endoplasmic reticulum
e) Ribosomes
f) Golgibodies
g) Mitochondria
h) Plastids
i) Microbodies
j) Spherosomes.

**B. Nucleus (cytoplasm + nucleus = protoplasm). It includes :**

a) Nuclear envelope
b) Nucleoplasm
c) Chromatin
d) Nucleolus

**C. Vacuoles**

**D. Flagella and cilia.**

**Defination** The protoplast is the living unit, actually the physiological unit of a cell, while the protoplasm is the essential living material that comprises different parts of it.

## . Structure of plasma membrane.

### * Probable Cause of difficulty

(I) Many models of cell membrane/ plasma membrane, regarding mode of arrangement of proteins and lipids, have been described in different text books causing conceptional error among students.

### * Explanation

1. Cell membrane/ plasma membrane is a selectively permeable membrane. It is usually composed of proteins and lipids.

Following two models are adequate to describe protein and lipid arrangement in plasma membrane.

- Classical Unit membrane structure proposed by Robertson (1959) and
- Fluid - mosaic model of Singer and Nicolson (1972). In the later model extrinsic and intrinsic proteins have been compared to icebergs floating in an ocean of phospholipid bilayer.

Lipids and intrinsic (integral) proteins are arranged in a mosaic manner to form a quasifluid biological membrane. They both have hydrophilic (polar) and hydrophobic (non-polar) groups. Due to amphipatic nature of integral proteins, polar heads protrude from the surface of the membrane, while non-polar regions are embedded in the membrane. These intrinsic proteins are capable of lateral diffusion in the lipid layer. The extrinsic globular proteins are soluble and can readily dissociate from the membrane. It completely remain out of lipid bilayer. The lipid bilayer has also dynamic properties. As proteins and lipids are not static, the cell membrane or the Plasma membrane is in a fluid state.

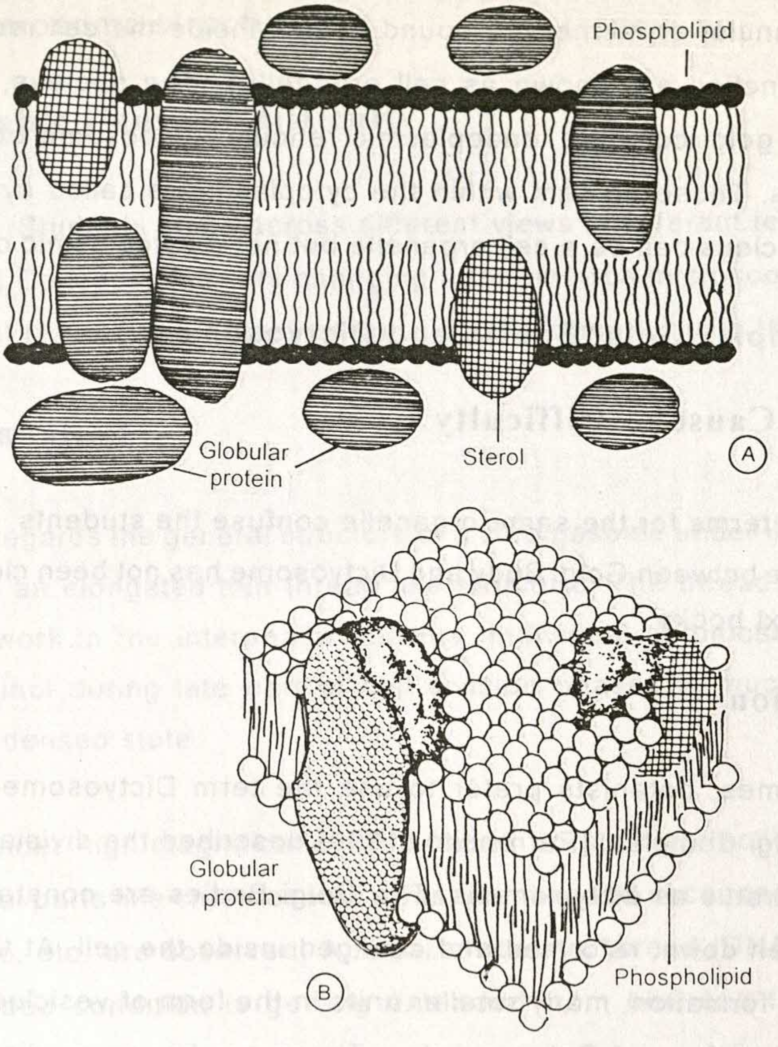


Fig.15. (A) Schematic representation of a section through a eukaryote fluid. mosaic membrane
(B) The fluid-mosaic model of Singer and Nicolson ( 1972): bacterial membrane.

## 4. Term Organelles

### * Probable Cause of Difficulty

(i) Lack of proper explanation in the text books.

### * Explanation

1. The correct statement should be

"The granular or membrane bound bodies inside the cell required for specialised function are known as cell organelles. The nucleus, plastids, mitochondria, golgi complex, endoplasmic reticulum, ribosome etc. are all cell organelles. Those present within the cytoplasm are called cytoplasmic organnels. Nucleus can be a cell organelle but not a cytoplasmic organelle.

## 6. Golgi complex/Golgi Bodies and Dictyosomes.

### * Probable Cause of Difficulty

(i) Alternate terms for the same organelle confuse the students.

(ii) Difference between Golgi Body and Dictyosome has not been clearly dealt with in text books.

### * Explanation

Sometimes, botanists prefer to use the term Dictyosome for Golgi Bodies or Golgi Complex. [Perroncito (1990) described the division process of Golgi apparatus as dictyokinesis. The Golgi Bodies are constantly being formed, broken down, reformed and changed inside the cell. At the time of its division or formation, many smaller units in the form of vesicles are seen on the formative face of Golgi complex. These are known as dictyosomes. The term "dictyosome" should be avoided. Only "golgi bodies" or "golgi complex" should be used.

## 6. "Energy Currency"

### * Probable Cause of difficulty

(i) It is a confusing statement. Sometimes used for the in presence of ATP.

### * Explanation

Often the term "energy coin/ currency" misleads the learners ATP :- Adenosine triphosphate (ATP) functions as a donor of phosphate group in cell energy cycle. ADP (Adenosine diphosphate) in the presence of enzyme acquires the high energy phosphate bond to become an ATP.

## 7. Chromosome structure

### * Probable Cause of difficulty

(i) Students come across different views in different text books.
(ii) Concept gradually changing after electron microscopic studies.
(iii) May be due to lack of up to date information with the teachers.

### * Explanation

(1) As regards the general structure of a chromosome under light microscope it is an elongated thin thread like structure. The threads coil to form a network in the interphase nucleus. Individual chromosomes are quite distinct during late part of cell division phases in much reduced and condensed state.

Under high magnification and based on staining techniques different structural parts like chromosome arms, primary and secondary constrictions, telomere, etc. are observed. A linear chromatin thread (DNA single thread) in a folded condition is getting extended from one end to other end of chromosome arms.

The metaphase chromosome appears to be made up of two distinct chromatids due to longitudinal separation. In each chromatid, the DNA thread or fibre is observed being folded longitudinally and transversely.

(2) Use of terms like pellicle, matrix, chromonemata (multistrand or fibres), chromomere etc. should be avoided.

(3) For clear understanding of a student, the "folded fibre model" for chromosome structure may be followed. [Ref. Du Praw's Model (1965)].

(4) A preliminary idea about nucleosome concept (Histone and DNA arrangement may be given to the students for better understanding).

The chromosomes of eukaryotes are made up of nucleoprotein material called chromatin. The nucleoprotein consists of nucleic acid whic is DNA and protein which are most often histones. It can be seen under the electron microscope that chromatin has "string of beads" structure and is made up of a number of repeating units. These units (the beads) have been called "nucleosomes" The nucleosome represents the latest chromosome model of DNA - protein association.

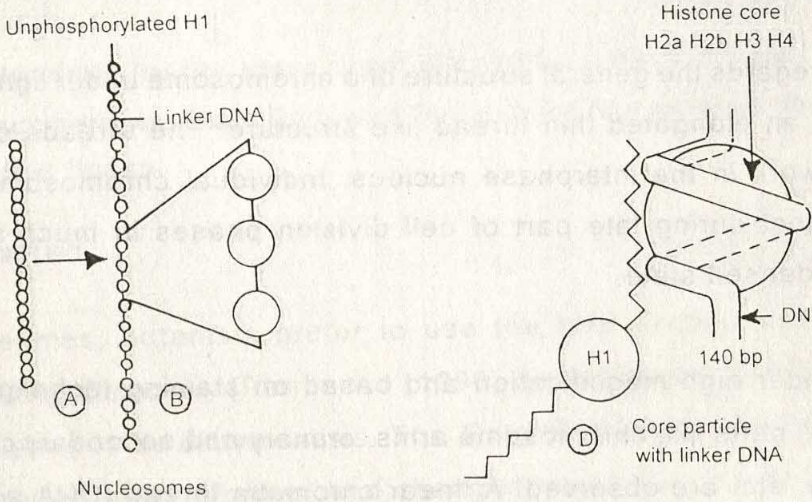


Fig.16. Structure of Chromosome (Nucleosome model)

## 8. Probables types of gamete formation from $F_1$ hybrid in a dihybrid cross

### * Probable Cause of Difficulty

The student lack in under standing about the recombination and resuffing of gene (factors) in meiosis.

### * Explanation

When two pure line parental genotypic forms are crossed the F1 hybrid is formed as follows.

Monohybrid cross

Parents YY × yy

Gametes Y ↘ ↙ y

Yy → $F_1$ hybrid

Dihybrid cross

Parents YYRR yyrr

↓ ↓

Gamets YR ↘ ↙ yr

YyRr — $F_1$ hybrid

Here ‘Y' AND ‘Y' or R and "r" called as allelic pairs or alleles.

Always allelic forms/paires are represented together side by side to express the genotypes of the organisms. This is easier and brings a clear understanding about the phenotypic expression of alleles/allelic genes.

In monohybrid cross, the $F_1$ hybrid gives rise to two types of possible gametes.

### * Explanation

When the $F_1$ hybrid in a typical mendelian dihybrid cross forms gametes the allelic pairs get separated in 4 possible combinations.

These 4 types of gametes after fertilization produce and phenotypes may be dominant or recessive in the $F_2$ generation.

## 9. Back cross and Test cross

### * Probable Cause of Difficulty

May be due to inadequate and proper transaction by the teacher the concepts has created confussion in the student's mind.

### * Back cross

When the $F_1$ hybrid is crossed with any parent all type form to develop the progeny, the method is called back cross.

### Test cross

When the $F_1$ hybrid is crossed with the double recessive pure line parental form (double homozygous recessive) the back cross is known as test cross. It helps to known the purity of the parental genotype.

## 9. Nucleic acids : The molecular model for DNA

### * Probable Cause of difficulty

(i) Lack of visualisation of DNA model and orientation of the polynucleotides in DNA strands.

(ii) lack of knowledge in the molecular structure of different components like phosphate, ribose sugar and nitrogenous bases and their bondings.

(iii) Right handed helical form of DNA along an imaginary axis.

## Explanation

DNA (Deoxyribo nucleic acid) is composed of two polynucleotide chains running antiparallel to each other. Phosphate group, deoxyribose sugar and nitrogenous purine or pyrimidine base constitute a nucleotide of DNA. The nucleotide without phosphate group is known as nucleoside. Phosphate - sugar, being arranged longitudinally, form the backbone of the polynucleotide while the base links to the first carbon atom of its deoxyribose sugar in horizontal manner. Always the sugar position is in reverse orientation in two complementary strands to give the antiparallel nature of DNA strands.

The nitrogenous base of one strand is connected horizontally with the base of complementary strand by the help of hydrogen bonds. There are 4 bases like Adenine (A), Guanine (G), Cytosine (C) and Thiamine (T) present in DNA structure. A and G are purine bases and C and T are pyrimidine bases. A forms two hydrogen bonds with T and G forms three hydrogen bonds with C in a DNA molecule.

DNA forms right handed helix along the imaginary axis. Major and minor grooves are formed at its lateral sides. When DNA under goes 360° rotation (one turn of helix) about 10 nucleotides are seen present in each turn, which is about 34A° in length.

2. A three dimensional Watson - Crick DNA model is essential for proper demonstration in class room.

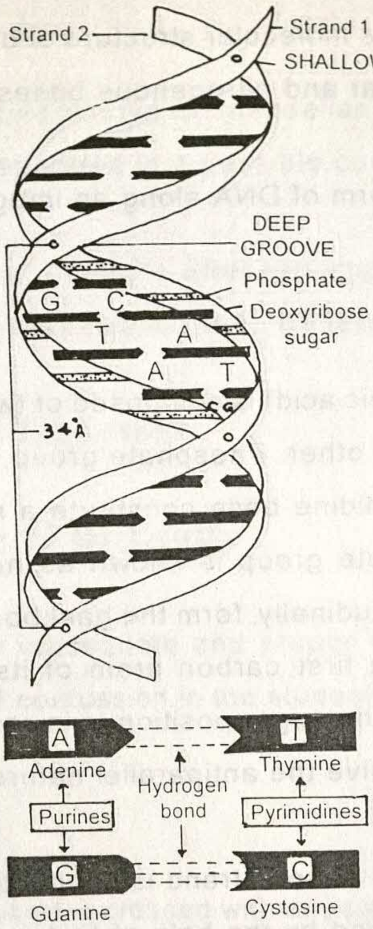


Fig.17. The DNA double helix

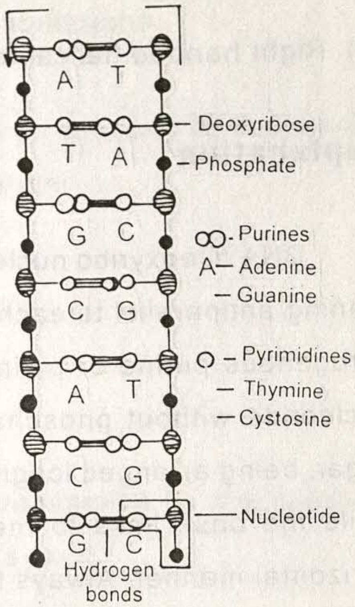


Fig Diagramatic representation of the DNA molecule.

## 10. DNA replication

### * Probable Cause of difficulty

(i) Use of certain technical terms in DNA replication confuses students : Complementary strands, semiconservative, $3^1 \rightarrow 5^1$ or, $5^1 \rightarrow 3^1$ direction

(ii) Lack of proper visualization.

### * Explanation

Models and study aids are to be incorporated to clarify the difficulties. Position of carbon atoms in the sugar and consequently $3^1 \rightarrow 5^1 \rightarrow$ and $5^1 \rightarrow 3^1$ direction are to be clarified.

### 11. Origin/ continuity of cell

### * Probable Cause of difficulty

Wrong interpretation and understanding of the terms origin and continuity of cell.

### * Explanation

1. Origin of cell pertains to the evolution of cell from a primordial soup.

2. Continuity of cell includes development of new cell from the pre-existing cell by cell division.

### 12. Concept of cell cycle and cell division

### * Probable Cause of Difficulty/ Error

(i) Students fail to differentiate cell cycle from cell division.

(ii) They describe cell division starting from prophase onwards.

(iii) They fail to understand when and how DNA duplication takes place.

(iv) Confusion exists between the number of chromosomes and amount of DNA after interphase.

(v) Students also get confused regarding orientation of chromosomes during metaphase of mitosis and meiosis.

(vi) Students lack understanding about the need of Meiosis-II.

### * Explanation

Understanding of cell cycle is very important. The cell undergoes a preparatory stage before entering into division. Interphase is the preparatory phase during which many biochemical processes such as RNA, protein and DNA synthesis take place. It is the longest phase in cell cycle.

The total amount of DNA duplicates during the 'S' period followed by synthesis of histone protein in $G_2$ period. Then the cell proceeds for division. The preparatory stage alternates with division stage to complete the cell cycle.

Karyokinesis and cytokinesis are the two steps of cell division.

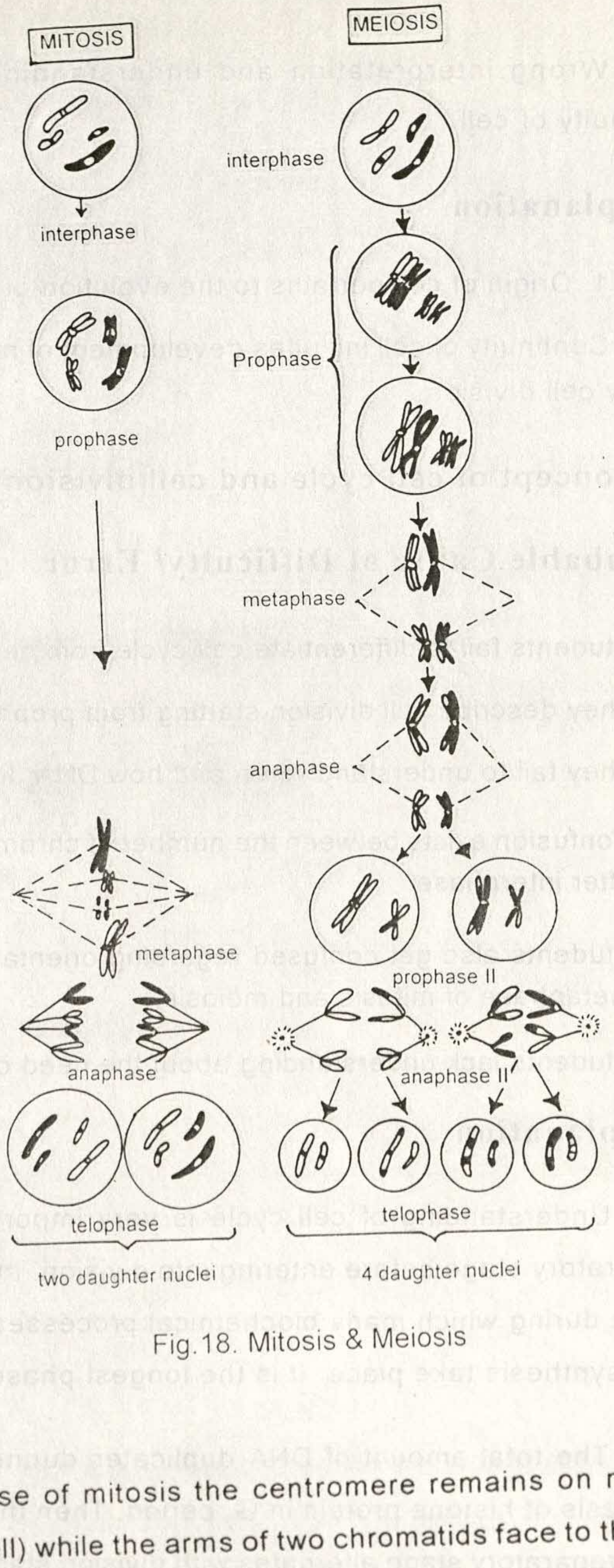


Fig.18. Mitosis & Meiosis

## Explanation

During metaphase of mitosis the centromere remains on metaphasic plate (equator of the cell) while the arms of two chromatids face to the opposite poles. Such orientation is called auto-orientation.

In metaphase- I of meiosis the cross over points (chiasma) remain on equatorial/ metaphoric plate while the centromeres of homologous chromosomes face to the opposite poles. This type of arrangement is called as co-orientation.

At the end of meiosis-I the homologous chromosomes reach the opposite pole is in two chromatic condition. For the separation of chromatids and formation of 4 gametic cells second stage of meiosis (i.e. Meiosis - II) is essential.

Interphase - I and Interphase - II in meiosis.

| | |
|---|---|
| Interphase - I | occurs before karyokinesis. During this period RNA, protein, DNA and histone protein syntheses take place. |
| Interphase - II | may or may not take place during meiosis. If at all it exists no RNA, DNA and Histone protein synthesis take place. |

## 13. Gene and gene action

### * Probable Cause of Difficulty/Error

The concepts are not well explained in the text book. Moreover while teaching topics such as chromosomes and DNA, these recent concepts one often overlooked by the teachers.

### * Explanation

Gene is considered as a segment of DNA consisting of specific nucleotides in a perticular sequence responsible for a specific character. In all eukaryotes and most prokaryotes gene is a DNA. In some viruses (plant/ animal viruses), the gene is RNA.

The total heriditary material present in an organism is divided into genome and plasmon. The genome is the hereditary material of the chromosomal complex. The plasmon is the total hereditary material outside the chromosome. The plasmagenes of plastids are called plastogenes, those of mitochondria chondriogenes.

Gene has been variously considered as a unit of recombination (recon), a unit of mutation (muton) and an unit of function (cistron).

### * Gene as a unit of recombination (recon)

On the basis of the work on Drosophila, it has been said that gene is the shortest segment of a chromosome that could be separated from its adjacent segments during crossing over. Gene is a part of a chromosome within which crossing over does not take place but it takes place between gases. The gene was thought to be an indivisible unit of a chromosome controling some phenotypic character. It is the smallest unit capable of recombining genetically. However with recent studies on bacteriophages, it has been observed that crossing over occurs within a gene and the unit of recombination is much smaller that it was conceived earlier.

### * The gene as a unit of mutation (muton)

The shortest chromosomal unit capable of undergoing mutation has been called the muton. The muton consists of one or many pairs of nucleotides within the DNA molecule. In many cases a gene mutation is a charge in a single nucleotide unit of DNA.

### * The gene as unit of functions (cistron)

The gene was considered to be the unit for coding the synthesis of a single enzyme. It was thus identified by its functional product, the enzyme. The one - gene - one - enzyme hypothesis has been expressed in several different ways. Since the gene forms a messenger RNA molecule, it can also be said that one gene forms one messenger RNA. In some cases however several genes form a single mRNA strand which is then said to be polycistronic. The concept has also been expressed as one gene - one protein since the messenger RNA molecule serves for coding of a protein (enzyme). It would be more correct to use the statement one gene one polypeptide chain, since an enzyme or protein may contain more than one polypeptide chain. The chains formed by different genes then aggregate to form the enzyme (protein molecule). Stahl has defined the gene as a polynucleotide chain consisting of segments, each controlling the expression of a particular trait.

## * Number of genes

The number of genes that an organism possesses depends on its complexities, viruses because of their simple physiology have few genes. For example the bacteriophage R17 has only three genes in its genetic RNA. The bacterial virus lambda ( $\lambda$ ) has about 40 genes and $T_4$ has over a hundred genes.

Though there is relationship between the number of genes and the complexity of organisms, there is no strict correlation between apparent genetic complexity and the DNA content per haploid nucleus. Some fishes and amphibians contain 10 to 20 times more DNA than humans. In *E.coli* the chromosome is about 1mm long containing 4000 genes and 4000 000 base pairs. The normal diploid human cell contains about 5 pico grams ($5 \times 10^{-12}$) of DNA which is equivalent to $5 \times 10^9$ (5 billion) base pairs and $5 \times 10^6$ (5 million genes).

## * Number of nucleotides in a gene

It is possible to find out the number of nucleotides in a gene if the molecular weight of the gene is known, since each base pair has a molecular weight of about 600. The average gene has about 900 - 1500 base pairs.

## * Loci and Alleles

A gene occupies a definite position within the chromosome. This position is called the locus. Since chromosomes exist in homologous pairs, each cell contains two kinds of genes which are found in pairs. The two members of a pair of gene are called alleles (allelomorphs). Usually alleles are alike but sometimes they may differ.

## * Gene Action

Genes act by controlling the structure and rate of production of specific proteins (enzymes). The DNA of each gene forms a complementary mRNA strand which attaches to the ribosomes. Hence it serves for arranging t RNA molecules in a specific sequence. Hence it serves for arranging t RNA molecules in a specific sequence. Since each t RNA molecule brings with it a specific amino acid, the sequence of amino acids is determined by the sequence of nucleotides in mRNA. This in turn is determined by the segnence of nucleotides in DNA. Because a series of enzyme controlled reactions determine traits in an organism, the structure of these enzymes is controlled by the genes, it follows that genes determine traits. The whole chain of events may be summarised as

**DNA ——→ mRNA ——→ Segnence of amino acids ——→ Traits**

(Gene) (Structure of enzymes)

## * Gene Regulation

All genes in the DNA do not operate simultaneously. Some remain active, others remain at passive state. Of several models known, Jacob and Monard (1961) proposed the operon model to explain the control of gene activity. It was assumed that there are three kinds of genes, Structural genes, oper genes and regulator genes. Structural genes are those that produce mRNA. Operator genes control structural genes by acting on switches in controlling mRNA synthesis. These different types of genes together constitute the operon. Regulator genes produce substances (repressors) which block the operator genes, So that mRNA synthesis by structural gene is prevented.

## * Teaching Method

The above concepts such as gene, gene action etc. should be taught after teaching of cell structure, chromosome and DNA. This can well be taught by demonstration - cum - discussion method using charts or suitable diagrams. Since the above concepts are likely to develop many questions in the minds of the students they should be encouraged to ask questions to clarify their doubts.

# MODEL QUESTIONS

1. Describe the structure of cell membrane. How it function ?

2. What are cell organnelles ? Describe the structure and function of any four cytoplasmic organnelles.

3. What is a cell cycle ? Describe the process of mitotic cell division.

4. Enumerate the structure and function of nucleus.

5. What are Non-living cell contents ? Describe their location and function in plant cell.

6. Bring out the differences between mitosis and meiosis with help of diagrams only.

7. Describe how you will be able to see chromosomes in any plant or animal material in your biology laboratory.

8. Draw a labelled diagram of a cell as seen under electron microscope.

9. Give a schematic representation (Genotype and Phenotype) of a Mendelian dihybrid cross between two plants having Tall and Red flowers and Dwarf and White flowers respectively upto $F_2$ generation.

10. Explain with the help of diagram why is the DNA molecule is comparable to a spiralling staircase ? Which three components make up the nucleotide.

11. What are semi-autonomous cytoplasmic organnele ? Write down their functions.

12. Why cells are considered as unit of life ? Bring out the differences between prokanryotic and eukaryotic cells.

13. Write down the structure and function of Cell organnelles concerned with protein synthesis.

14. What is the significance of meiosis in the life of plants and animals ?

15. Why did Mendel choose garden peas for his experiments ? How did he make sure that the plants were true breeding ?

16. Distinguish between

a) Genotype and Phenotype
b) Monohybrid cross and Dihybrid cross
c) Test cross and Back cross
d) Dominant and Recessive Alleles.
e) Homozygous and Heterozygous

17. How plant cells are different from animal cells ?

18. How RNA is different from DNA in terms of structure, function and location.

19. What is a hybrid ? How the hybridisation experiments are useful to us ?

20. What is a hybrid ? Write in 5 lines the importance of crossing over.

21. What is a gene and how do you differentiate between gene and allele.

22. Establish the relationship between cell, chromosome and gene.

23. what is the difference between recon, muton and listron ?

24. Choose the most correct answer

1.Cell theory was proposed by -
(a) Robert Hooke (b) Schleidew and Schwanr (c) Watson and crick
(d) Beadle and Tatum.

2.Protoplasm is a -
(a) Liquid (b) Colloidal solution (c) Crystallocolloidal (d) Grannular

3.Cytoplasmic connection between adjacent cells are -
(a) Endoplasmic reticulum (b) Cell wall (d) Plasmodesmata (d) Micro fibrils

4.DNA is found in -
(a) Mitochondria (b) Ribosome (c) lysosome (d) Golgi Body

5.What is absent in mature mammalian RBC.
(a) Nucleus (b) protein synthesis (e) Endoplasmic reticulum. (d) Growth.

6.Plant cell differs from animal cell having -

(a) Cell wall, (b) Mitochondria (c) Ribosome (d) golgi complex.

7.The subphsdes of cell cycle are in the following order

(a) $G_1$ S $G_2$ M (b) $G_1$ $G_2$ S M (c) $G_1$ S M $G_2$ (d) $G_2$ M $G_2$ S

8.Which one of the following structures is found in mitochondria.

(a) Condriosome (b) peroxisome (c) Oxysomes (d) Nucleosome

9.The synaptinemal complex is associated with.

(a) Polytene chromosome (b) Lampbrush chromosome (c) Paired meiotic chromosome (d) mitotic chromosome.

10. End product of glycolysis

(a) Lactic acid (b) Pyruvic Acid. (c) Acetyl Co. A (d) Oxaloacetec acid.

25. Observe the relationship between first pair of words and then fill in suitable word in the fourth place

Chloroplast; Photosynthesis; Mitochondria ______________

Balcteria : Prokaryote : Human cell____________________

Protein : Aminoacid : DNA ____________________

Plants : Starch : Mammals ________________

26. Match words from coloumn A with suitable words form B.

| (A) | (B) |
|---|---|
| Acid hydrolases | Mitochondria. |
| Protein synthesis | Lysosomes. |
| Cristae | Ribosome. |
| Chlorophyll | Grana. |

27. Fill in the blanks with appropriate words.

1. Chemically, the ribosome is formed of _________ and __________
2. Power house of the cell is ___________
3. DNA has ________ base instead of Uracil.
4. Fluid mosaic model was proposed by ______________
5. Meiosis occurs in ___________ cells only.

# VI. INTRODUCING ZOOLOGY AND ANIMAL LIFE

## DIFFICULT CONCEPTS

Different branches of zoology and their applications.

### * Probable Cause of Difficulty/Error

(i) The different areas are not placed in order of importance in text books.

(ii) Proper emphasis has not been given to the applied areas.

(iii) Many applied areas such as biofertilizer, biocontrol, and biopesticides are overlooked.

**Biofertilizer** - The organisms which bring about soil nutrient enrichment by fixing nutrients such as nitrogen in the soil. The major sources of biofertilizers are bacteria, cyanobacteria, fungi, lichen and mycorrhiza etc.

Example (1) Legum - Rhizobium symbiosis; (2) Azolla - Anabaena symbiosis; (3) Loose association of nitrogen fixing bacteria.

(Example : *Azospirillum lipoferum* a nitrogen fixer with the roots of certain Brazilian grasses and maize).

### Biological Control

It involves the control of a living organism or plant with another living organism. For example, biological control of weeds involves utilisation of insects that would feed selectively on a weed or use certain microorganisms which will produce diseases in the weeds & eliminate them. In India & Australia the over growth of cacti has been checked by the introduction of cochaired insect *(Cactoblastics cactorum)*. Many insect larvae are being controlled by the use of viruses.

The first bioherbicide was developed in 1981. It is a micoherbicide based on fungus *Phytophora palmivora* that controls the growth of milk weed vines in citrus orchards.

## Bio-insecticides

(1) Roots of *Derris elliptica* are used as effective insecticides in India.

(2) Foliage coated with extract of neem repell beetles & leaf eating pest.

## Insect hormones

Scientists have been employing insect hormones for pest control. One such group of compounds are the pheromones secreted by the female insects and detected by the antennae of the males. Traps containing pheromones of gypsy moths are placed in the infested field to trap the males which are thus not available for reproduction - consequently there is decline in the population.

## Biotechnology

It is the exploitation of living organisms or their parts their of to get products in industrial scale at a low cost. It is an interdisciplinary area and it owes its advancement in the last two decades to the spectacular developments in specific fields, microbiology, biochemistry immunology, molecular biology, genetic engineering etc.

## Yeast and Alcohol

During mid nineteenth century, Louis Pasteur showed that beer and butter milk are the products of fermentation, brought about by yeast; a microscopic single celled organism *(Saccharomyces cerevisiae)* mixed with liquid broth.

Alcohol from the fermented plant juices was the first product of biotechnology. Microbes are being used in a number of ways; for preparation of bread, yogurt, buttermilk, curd, cheese and vinegar etc. With the advances in the field of biology; microbiology, biochemistry, molecular biology, immunology, genetic engineering and chemical engineering etc. a variety of products have been produced. Some of the products are yeast, alcohol, enzymes, antibiotics, vaccines, growth hormones, amino acids and organic acids (lactic, citric, and gluconic acids).

## Applications of Biotechnology

Biotechnology is now aimed to solve three major problems of mankind; the hunger, sickness and energy.

(a) Food - The important foods such as Bread, Dosa, Soya, Sauce etc. are the products of microbial activity.

(b) Dairy Products - Dairy products include yogurt, curd, cheese and butter etc. These preparations are based on scientific strains of microorganisms.

(c) Alcoholic Beverages - For the preparation of beer, wines, whisky and alcoholic products.

(d) Non alcoholic beverages such as coffee and tea due to microbial fermentation .

(e) Sewage treatment - Different types of bacteria, fungi & algae play important role in the removal of organic matters from the sewage.

(f) Biogas - It is produced by fermentation of cowdung, farm refuge, garbage etc. by the methanogenic bacteria in anaerobic condition. The organic remains of biogas plant are used as manure.

(g) Organic acids - Acids such as lactic, gluconic, acetic and citric acids are obtained by fermentation technology.

(h) Enzymes - Enzymes required for industrial and medical use are available from microbial processes.

(i) Hormones - Insulin, growth and other hormones are mostly synthesized from the microbes through the process of genetic engineering.

(j) Vitamins - Some vitamins like $B_2$, $B_{12}$ are the products from microorganisms.

(k) Antibiotic - A number of antibiotics are derived from the fermentation of organic compounds.

(l) Vaccines - Vaccines are used for providing immunity against important diseases. They contain modified or inactivated or killed pathogens or their antigens.

(m) Tissue culture - These methods are being used for clonal propagation, woody plants, improvement of agriculture, forestry, induction of mutation, resistance etc.

(n) Transplants - Test tube babies and embryo transplant techniques are useful tools for rapid multiplication & production of genetically improved superior varieties.

(o) Genetic engineering - It is a technique through which genetic make up of an organism is artificially modified by incorporating a piece of foreign DNA into its cell. It is also known recombinant DNA technology and it brings about improvement of genetic make up of an organism.

(p) Monoclonal antibodies - Antibodies against pathogens can be obtained from clonal culture of microbes i.e. Antibodies obtained from a single source targeted against a specific pathogen.

(q) Steroids - These are the fat soluble organic compounds commonly used in pharmaceutical industries.

## Bio-active Substances

These are the extracts from animals for the benefit of animals and human beings. Further, these substances possess medical and pharmaceutical importance.

### (1) Snake Venom

It used in modern days for the treatment of deadly diseases like Cancer. Antivenin is used in treatment of snake bite is prepared from snake venom itself. In U.S.A. several massage oil to relieve muscular pain is prepared from body of Rattle snake.

**(2) Iodine**

Iodine is obtained from Sepia and used in many fields of medical sciences.

**(3) Blood of limulus (king crab)**

In recent years, medical science has used Limulus sp. for a potential source of bio-active substance; a diagnostic reagent, the Limulus Amoebocyte Lysete (Lal) from its blue blood. The reagent is highly sensitive and useful for the rapid and accurate assay of gram negative bacterium. Lal has been proved a valuable diagnostic reagent in the detection of endotoxins in several pharmaceutical products, especially injectebles. The diagnosis of gram negative bacteria associated with the Cirrhosis, Meningitis, Endopthalmities, Dental problem, Urinary infection, gonorrhea, typhoid fever and Seplicesmia is quite effective with Lal, traditional practice.

2. Ambiguity in classification

## Probable Cause of Difficulty

(i) The system of classification of living organisms provided by Linnaeus, into two kingdoms is outdated. (ii) Recent classifications are not clearly described in the text.

## Explanation

In modern days Whittacker (1969) has proposed five Kingdom classification and this may be followed to avoid confusion. The classifications is based on complexity of cell structure, Phylogenetic relationships and mode of nutrition. For example, Phylum - Protozoa carrying unicellular, eukaryotic, saprozoic, holozoic or autotrophic organisms is included in Kingdom (1) Protista instead of non chordates.

The Blue green algae, other bacteria, unicellular, prokaryotic organisms are included in (2) Monera

The multicellular syncytial saprozoic mushrooms are included in (3) Fungi.

The multicellular flowering, non flowering plants are included in (4) Plantae

All metazoans are included in (5) Animalia.

It is further suggested that for the better remembering the teaching of classification should be limited to classes only in Invertebrates and Vertebrates at +2 level, considering the vastness of broad out-line of classification.

### 3. Rules of nomenclature

Example : The zoological name of Indian frog is *Rana tigerina*

## Explanation

The International Commission of Zoological nomenclature should be strictly followed. The generic name is 'Rana' and the specific name is tigerina. While writting these two names the generic name, should start with capital letter 'R' and the specific name should start with small letter 't'. Both the words should be underlined separately as, at the time of writing the zoological names, we do not use italic letters.

### 4. Theories of locomotion in Amoeba

**Probable cause** Many theories creat confusion.

## Explanation

Some of the old theories such as; (1) contraction theory (Dellinger), (2) Surface tension theory (Berthold) and Rolling movement theory (Jennings) are not reflecting the accepted concept of locomotion.

The following most acceptable concept of locomotion may please be taught to the students.

### (1) Sol-gel theory (Hymen)

This theory of locomotion is based on the convertible nature of plasmasol to plasma gel and vice versa, which enable the animal to produce pseudopodia, the locomotory organ.

### (2) Molecular Theory (Gold Acre & Lorch)

This theory explains the process of gelation and solation on the molecular basis. When the protein molecules are in unfolded state and linked with each other in the form of a chain forms the gel. But when they are in folded state and lie freely form the sol.

## 5. Economic importance of Earth worm

### * Probable Cause of Difficulty

Utilisation of earthworm in agriculture as vermifertilizer, vermiprotein and vermicomposting and in medicine are not highlighted.

### * Explanation

Emphasis may be given to the economic importance of earthworm in detail as earthworm helps in making the soil soft, porous and fertile by their castings. It is highly fertile in nature. In accordance with ancient Ayurvedic and Urani Medicine system, earthworms are used in preparing various drugs for the treatment of kidney stones, pile, jundice, pyorrhoea and rheumatism.

## 6. Systematic position of cockroach

- **Probable Cause of Difficulty** Confusion of in the placement of cockroach in correct order.

### * Explanation

In some of the test books, cockroach is placed under order. Dictyoptera but it should be under order-orthoptera, as it possesses all the salient features of order-orthoptera.

## 6. Compound eye and vision in cockroach

* **Probable Cause of Difficulty** Poor understanding of mosaic vision among students.

### * Explanation

While discussing the external features of Cockroach more emphasis may be given on structure of Omatidium and mosaic vision.

A pair of compound eye each having about 2,000 small hexagonals called facets are persent is cockraoch. Below each facet there is a narrow 3 and columnar series of minute structures which together constitute a unit of sight called ommatidium. Thus each eye composed of about 2,000 ommalidia. The eye of this type is called compound eye.

The hexagonal facets present in the surface of eye look as a biconvex lense. Two corneagen cells are present below the lens. Between these cells a situated elongated cone cells, that surround a structure called crystalline cone. A spindle shaped structure called rhabdome is present below the crystalline cone. The rhabdome is surrounded by seven long cells called retinular cells. The rhabdome and retinular cells together form receptor region of the compound eye. Below this region is a basement membrane upon which rhabdome and retinular cells get support. Nerve fibres from optic nerve are attached to the base of each retinular cells.

Each ommatidium form some of the part of the image. Thus the complete image of any object is composed by many small images. This type of image is called apposition image and Such vision is known as mosaic vision.

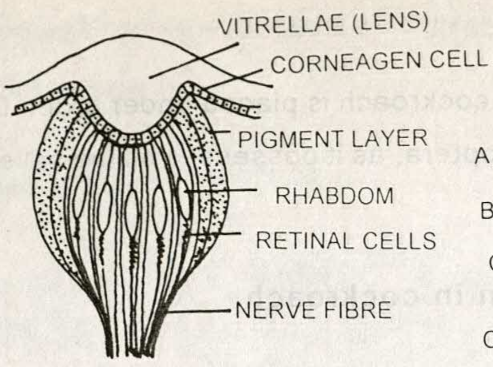
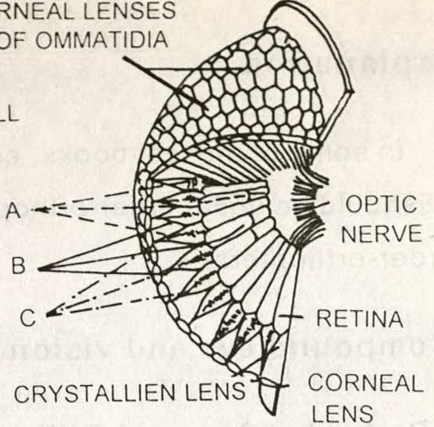


Fig.19 Cockroach.V.S. of an ocellus



Cockroach. Longitudinal-section of a part of the compound eye and the rest in surface view.

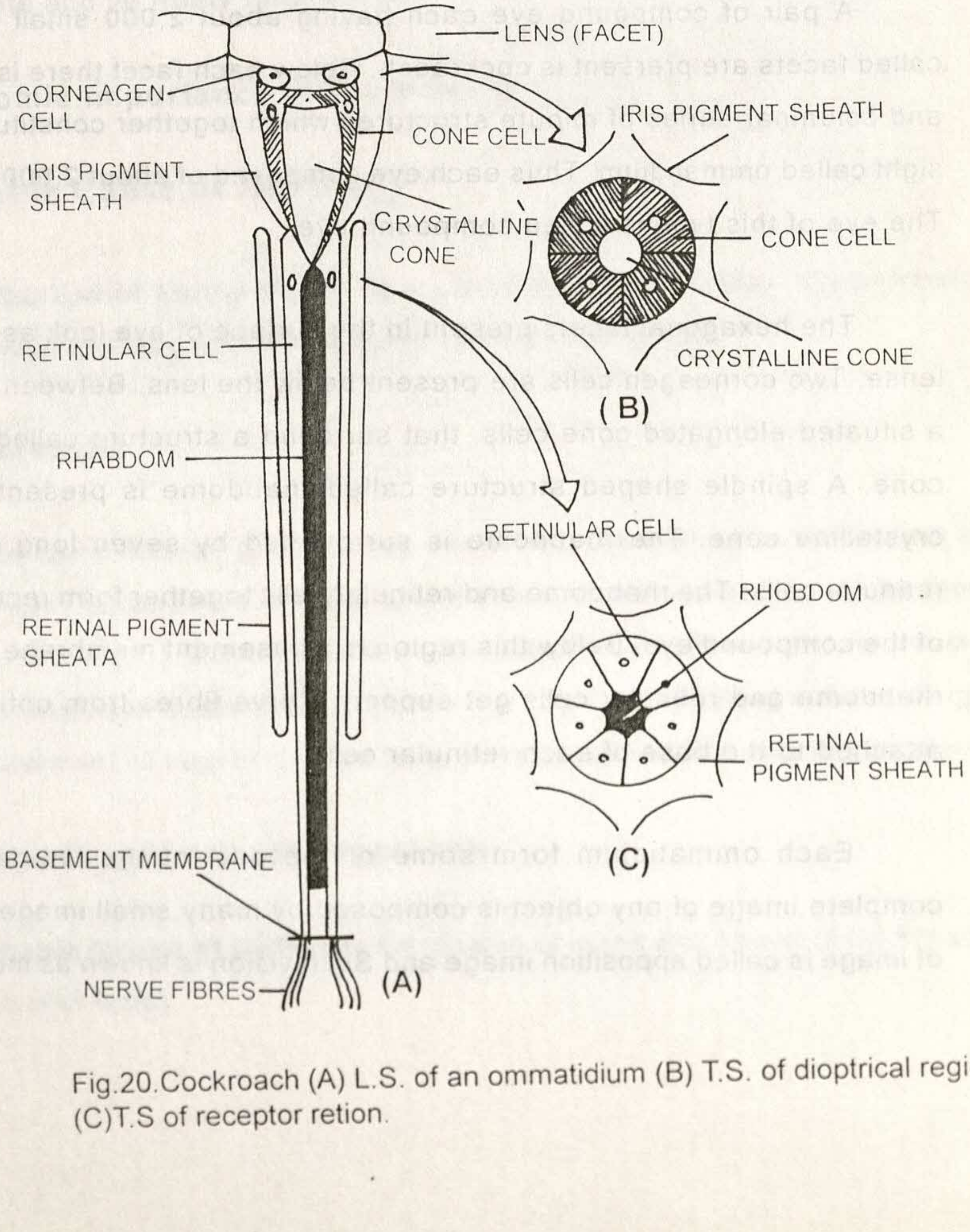


Fig.20.Cockroach (A) L.S. of an ommatidium (B) T.S. of dioptrical region (C)T.S of receptor retion.

# MODEL QUESTIONS

1. What is Zoology ? Name the various branches of Zoology with their importance .

2. Is the study of Zoology beneficial to us ? If so, enumerate your answer with suitable examples.

3. (a) If Amoeba is cut into two pieces, will it die ? If not, give reasons with justification.

   (b) What will happen, if Amoeba is transferred to sea Water ?

4. What is a pseudopodium ? How is it formed ? Explain the most acceptable modern theory of pseudopodia formation.

5. How Amoeba propagates in unfavorable and favourable conditions ?

6. Is malaria parasite reproduce by asexual mode ? Name the host where it completes the asexusal reproduction and how ?

7. In what way, the structures of different ectodermal cells are modified to help hydra to perform different functions ?

8. What is a cocoon ? How it is formed in earth worm. Give detail account of the system which is associated with cocon formation.

9. What is excretion ? Describe the structure and functions of the system which is responsible for excretion in earth worm.

10. (a) Differentiate between three Chambered and four chambered hearts. Illustrate your answer with suitable examples and diagrams.

    (b) What is portal system ? Point out the differences between Renal and Hepatic portal system with suitable diagram.

11. What do you mean by double circulation ? Illustrate your answer showing the mechanism of blood circulation in mammal.

12. What is the unit of vertebrate kidney ? Is there any difference between the structure kidney of frog, rabbit, and him an buings ? Explain through diagrams.

13. Draw a neat labelled diagram of the following.

a) L.S. of heart of frog.
b) L.S. of heart of rabbit.
c) T.S. of earthworm passing through phasyrix.
d) T.S. of earthwarm passing through gizzard.
e) T.S. of earthwarm passing through typhlosole.
f) Life cycle of plasmodium in man.
g) Life cycle of plasmodium in mosquito.
h) L.S. of body wall of hydra.
i) Septal nephridia of earthwarm.
j) Mouth parts of cockroach.

14. Write notes on : (In two sentences)

a) Binomial nomenclature.
b) Two system classification ?
c) Five kingdom concept.
d) Rules of nomenclature.
e) Genus and species.
f) Class and phylum.
g) Osmoregulation

15. Match the words from coloumn A with B

| (A) | (B) |
|---|---|
| Encystment | pre-erythrocytic schizogamy. |
| Sporulation | Incubation period |
| Binay fission | Exflagellatum |
| Exo-erythrocytic cycle | Nematocyst |
| regeneral on | Nutritive muscular cell. |
| Amphicoelons vertibrae | Ultra filtration. |
| SA node and AV node | Sperenatheum. |
| Important measure to control of malaria. | Use of earthworm in Bio-degradation. |

16. Fill in the blanks

a) The zoological name of an animal comprises ________ and ___________

b) Binomial nomenclature was established by

c) ________ is known as the father of zoology.

d) Study of insects is known as ______________

e) Different types of animal parasites are studied under _______________

f) Study of bones is called ____________

g) Study of fishes is called ____________

h) In earth worm, excretion is carried by ______________

i) Clitellum is extended from ________ to _________ segments.

j) Fertilization in earthworm is ____________

k) In frog, the winter sleep is called _______________

l) The poisonus gland present in toad is called __________.

17. Fill in the blanks choosing the correct word (s) from the bracket.

a) Hydra is a _______________ animal.
(diploblastic, triploblasic, monoblastic)

b) The body cavity of hydra is known as _____________
(coelom, gastrovascular cavity, blastocoel)

c) Acetabalum is found in __________
(radio-ulna, pelvic girdle, pectoral girdle)

d) Total number of vertebrae in the vetebral column of frog is _______
(twelve, nine, ten)

e) The transport of oxygen takes place in the blood through ___________
(WBC, RBC, thrombocytes, homones)

f) Leucocytes help in ___________
(digestion, excretion, phagocytosis, pinocytosis)

g) The deoxygenated blood in carried by __________ to lungs. (pulmonary artery, systemic arlery, ulmonary vein, carotid artery)

h) The cavity of lung is divided in numerous chambas calles as _____________ (infundibular folds, alveoli, mesenteries)

i) The gaseous exchange at the respiratory surface is known as _________ (tissue respiration, cutaneous, breathing)

j) In rabbit, the right lung has _________ lobes (one, two, three, four)

k) There are _____ pairs of cranial nerves in frogs). (five, two, three, four)

l) Corpus callosum is found in __________ (cerebellum, cerebrum, diencephalon)

m) The anterior choroid plexus is situated in the roof of __________ (diocoel, optocoel, rhinocoel, metacoel)

n) The name of the excretary unit of the kidney is known as _________________(seminiferous tubule, uriniferus tubule. nephridium, Bowman's capsule).

o) Glomerulus is present in _______ (ovary, kidney, Bowman's capsule, testis).

p) Sertoli cells are found in _____________________ of mammal. (kidney, testis, ovary, egg)

q) Interstitial cells produce _______________ hormone, which is responsible for the development of secondary sexual characters in male (progesterone, testosterone, thyroxine)

## 18. Very short question (Answer in one or two lines only)

1. Which is the Y shaped bone in the skull of frog
2. Where cellulose is digested in rabbit.
3. What are lacleals.
4. In which animal, cutaneous respiration is seen.
5. What is Duramatter ?
6. What is foramen of Monro ?
7. What is fossaovalis ?
8. Where is located the loop of henle ?
9. What are cells of Leydig ?
10. What is Graffian follicle ?
11. In which snake does third upper lip should touch eye and nostril.
13. What are the common poisonous snakes of India, write any three ?
14. How many spiracles are present in fishes.
15. In which fish heterocercal tail is present.

## 19. Write short notes on the following

1. Preerythrocytic cycle
2. Exoerythrocytic cycle
3. Schizogony
4. Cryptomerozoites
5. Ookinete
6. Sporogony
7. Metacryptomerozoites.
8. Gametogony
9. Portal System.
10. Double circulation.

## 20. Short type (Answer in one line/word only)

1. Which protozoa causes malaria in man.
2. Which is the primary host of malaria parasite
3. Where ookinetes are formed.

4. What is the duration of incubation period in *Plasmodium vivax*
5. In which segment of earthworm, ovaries are present
6. In which segment of earthworm, female genital apartures are present.
7. Give an example of entero nephric nephridia
8. In which segments pharyngeal nephridia are present in earthworm.
9. Name the blood pigment of earthwarm.
10. What is the name of the first body segment of earthworm.
11. Give one example of exonephric nephridia of earthworm.

**21. Differentiate between**

1. Garmetogony and sporogony
2. Pe-erythrocytic and exoerythrocyctic cycle.
3. Gametocyte and gametes
4. Macrogameto cycle and Microgameto cycle.
5. Zygote and ookinete
6. Binomial and trinomial nomenclature
7. Two kingdom and five kingdom classification
8. Artery and vein
9. Myogenic and neurogenic heart
10. Mitral valve and semilunar valve.

# VII. PHYSIOLOGY AND BIOCHEMISTRY

## DIFFICULT CONCEPT(S)

### 1) Difference between enzymes, hormones and vitamins

### * Probable Cause of Error/Difficulty

Not well explained in the text. Teachers do not emphasize the differences during teaching in the class room.

### * Explanation

**Enzymes**

Enzymes are biocatalysts (mostly proteneous in nature) of a highly specialised class which control large number of biochemical reactions.

**Properties of enzymes**

a) Enzymes do not start chemical reactions, but they accelerate them.

b) Enzymes are highly specific in nature i.e. a particular enzyme reacts and catalyses the reaction when a specific substrate for the same enzyme is present.

c) Enzymes function at very low concentrations but the rate of the reaction is directly proportional to the enzyme concentration if other factors are not disturbed.

d) Enzymes mostly require co-factors or co-enzymes for their activity.

e) Some enzymatic reactions are reversible in nature

f) Enzymes have very high molecular weight.

g) Enzymes are not used up during reactions catalysed by them and appear unchanged at the end of the reaction.

Enzymes are generally named accoridng to the substrate they attack (eg. maltase catalyses maltose) or the type of reaction they catalyse (e.g. oxidases catalyses oxidation reaction).

## Hormone

Hormone is a chemical messenger secreted in trace amount by endocrine tissues and carried by the blood to a target tissue, where it stimulates a specific biochemical or physiological activity or activities.

### Properties of Hormones

1. Hormones are low molecular weight compounds. These may be aminoacid derivatives, amines, low molecular weight proteins or small sized fatty acid.
2. Hormones are soluble in water, so that these can easily be transported by blood.
3. After the function is over, the hormones are destroyed or inactivated and excreted
4. They act in very low concentration
5. Hormones are non-antigenic
6. Hormones act as coenzymes in the tissue.

Both hormones and enzymes regulate the body function, but the two differ from each other in the following characters.

| Enzymes | Hormones |
|---|---|
| 1. Almost always protein in nature | 1. May be protein or amine or steriod in nature |
| 2. These are macromolecules with hight molecular weight. | 2. These have low molecular weight. |

***Cont..***

| Enzymes | Hormones |
|---|---|
| 3. Enzymes act as bio-catalyst | 3. Hormones act as chemical co-ordinator or messenger |
| 4. These are non-diffusible through cell membrane | 4. These are diffusible through cell membrane. |
| 5. These act intracellularly or, carried by some ducts to another site. | 5. These are usually carried by blood to a target organ. |
| 6. These take parts in metabolic reactions directly by enhancing the rate. | 6. These may be excitatory or inhibitory and play their role as co-enzymes. |
| 7. These catalyse, usually reversible reaction. | 7. These control reactions which are not reversible |
| 8. Reaction rate due to enzyme increase with increase in their concentration upto a limit. | 8. Deficiency or excess of hormone causes metabolic disorder and disease. |
| 9. These act quickly | 9. Some act quickly and some are slow acting. |
| 10. Not used in metabolic functions. | 10. Used in metabolic functions. |

However, the hormones act by activating the enzymes in the target cells.

For example : when the hormone binds with a specific receptor on the membrane surface of the target cell, a portion of the receptor which protudes to the interior of the cell membrance activates the enzyme adenylate cyclase which in turn causes conversion of cytoplasmic ATP into Cyclic AMP. The Cyclic AMP in turn activates still other enzymes inside in cell, for expression of the particular hormone action.

## Vitamins

A Vitamin is an organic compound needed in small quantity (hence also known as micronutrients) for operation of normal bodily mechanism. Polish biochemist C. Funk (1911) first coined the term "vitamin".

Vitamins may be fat soluble or water soluble

### A. Fat soluble vitamins

These are oily in nature and soluble in organic solvents e.g. chloroform but insoluble in water. These are of following types

#### (a) Vitamin A

It is present in fish, cod liver oil, shark liver oil, egg yolk, milk, butter, clarified butter (ghee), green vegetables (carrots, tomatoes and green leafy vegetables) etc.

It's deficiency causes xeropthalmia, night blindness (nyctolopia), Keratomalacia, sterility and retarded growth.

#### (b) Vitamin D or Calciferol

It is present in fish liver oil (animal sources) and also synthesized in the skin from a cholesterol derivative (ergosterol) in the presence of ultraviolet radiations of sunlight.

It's deficiency causes rickets in children and osteomalacia in adults

#### (c) Vitamin E or Tocopherol

It is present in vegetable seed oils and green leafy vegetables.

It's deficiency causes reproductive failure and degeneration of muscles in many mammals and increases fragility of erylthorcytes in man.

### (d) Vitamin K

It is present in vegetable seed oils and green vegetables like spinach, coriander leaves and radish tops. It helps in blood coagulation, so it's deficiency causes profuse and prolonged bleeding.

## B. WATER SOLUBLE VITAMINS

### (a) Vitamin B-complex

Vitamin $B_1$ (Thiamine)

It is present in yeast, cereal grains, pulses, nuts, liver and meat

It's deficiency produces Beri-Beri in man

Vitamin $B_2$ (Riboflavin)

It is present in milk, yeast, liver, yogurt (Dahi), pulses and green leafy vegetables. Its deficiency produces inflamations of the tongue (Glossitis), fissures in the lips (Chellosis) and skin disease (Keratitis)

Vitamin $B_3$ or pantothenic Acid

It is present in green leafy vegetables, molasses, liver, egg yolk and milk. It's deficiency causes dermatitis in chickens and poor growth, early aging and greying of hair in man

Vitamin $B_5$ or Niacin or Nicotinic acid

It is present in cereal husk, peas, beans, green leafy vegetables, liver, fish, milk and egg yolk. It's deficiency causes Pellagra characterised by dermatitis, scaly skin, intestinal and mental disorders.

Vitamin $B_6$ or Pyridoxine

It is present in yeast, cereal, liver, eggs and green leafy vegetable. It's deficiency causes dermatitis, paralysis and death of rats and convulsions and anaemia human in case of the children.

Vitamin $B_7$ or Vitamin H or Biotin

It is present in vegetables, fruits, milk, liver, egg yolk. It's deficiency causes dermatitis, muscular pain, and growth failure.

Folic acid or vitamin $B_9$ or vitamin M

It is abundantly present in green leafy vegetables like spinach, cabbage and is also synthesized by colon bacteria. It's deficiency causes megaloblastic anaemia and gastro-intestinal diseases.

**Choline**

It is present in egg yolk, liver, kidney, leafy vegetables and germinating cereal grains. It's deficiency causes cirrhosis in liver and hemorrhagic changes in kidneys.

Vitamin $B_{12}$ or Cyanocobalamine

It is present in meat, liver, fish and synthesized in human colon. Generally not found in vegetables. Its deficiency causes pernicious anaemia characterised by malformed RBCs.

### (b) Vitamin C or Ascorbic acid or Anti-scorbutic acid

It is present in citrous fruits, pineapple, grapes, leafy vegetables like spinach and green pepper. It is absent from animal sources.

It's deficiency causes scurvy, which is characterized by bleeding gums, loss of weight and poor wound healing.

## 2. NOMENCLATURE AND CLASSIFICATION OF ENZYMES

Usually enzymes are named by adding the suffix - are to the name of their substrate, for example, Urease catalyses hydrolysis of urea, But many enzymes have been given names that do not denote their substrate, e.g. Pepsin, Trypsin and Ptyalin etc. Sometimes, the same enzyme is known by two or more names or two different enzymes have been given the same name. Due to all these ambiguities, an international basis for naming and classifying enzymes have been adopted by I.U.B. (International Union of Biochemistry). According to this, enzymes are placed in six major classes, each with subclasses based on the type of reactions, they catalyse.

International system of enzyme classification

Class - 1 - Oxido-reductases - It acts by removing or adding electrons ($H^+$) i.e. Oxidation reduction reactions. For example- cytochrome Oxidase, alcohol dehydrogenase.

Class - 2 - Transferases - These transfer functional group, carbon group, phosphate group, sulpher containing group. e.g. glutamate-pyruvate transamiase.

Class - 3 - Hydrolases - These take part in hydrolysis reactions i.e. breakdown, by introduction of water and also breakdown of covalent bonds e.g. digestive enzymes like amylase, cellulase, sucrase etc.

Class - 4 - Lyases - These catalyse the cleavage of specific covalent bonds and removal of groups without hydrolysis. These act on C-C, C-O, C-N, C-S, C- Halide bonds e.g. histidine decarboxylase, (act on C - C bond in histidine to form $Co_2$ and Histamine)

Class - 5 - Isomerases - Theses catalyse isomerisation reaction like the re-arrangement of molecular structure to form isomeres. e.g. phosphohexisomerase isomerese acts on glucose - 6 - phosphate to form fructose - 6 - phosphate.

Class - 6 - Ligases - These catalyse formation of bonds like C - C, C - S, C - O, C - N by condensation reactions coupled to ATP cleavage. e.g. Pyruvate carboxylase which helps to combine pyruvate and $Co_2$ to form oxalo-acetate.

Difference between Enzymes and Vitamins.

| Vitamins | Enzymes |
|---|---|
| 1. Animals are unable to synthesize vitamins and obtain these from diet. Only vitamin D can be synthesized in the skin, folic acid and vitamin $B_{12}$ by the colon bacteria. | 1. Enzymes are produced in the organs, where they are used. |
| 2. Chemically, vitamins are organic acids, amines, amino acids, esters, alcohols even steroids. | 2. Enzymes are almost always proteins. |
| 3. Vitamins act as co-enzymes and help in catalysing biochemical reactions. | 3. Enzymes act as biocatalysts for various chemical reactions |
| 4. The dietary deficiency of each vitamin, produces deficiencies or disease but excess are excreted out. | 4. Enzymes are required in small quantities not effective in higher concentrations. |
| 5. These are consumed during the process. | 5. Enzymes are not consumed during the reaction. |

**Method of Teaching** These topics can well be taught through critical discussion with adequate example.

3. **Blood coagulation**

## * Probable Cause or Difficulty

(i) Not clearly discussed in the text books/ curriculum.

(ii) Lack of correct explanation in the class room.

## * Explanation

### (a) Classical Concept

The process starts with

(1) Liberation of thromboplastin by damaged tissue and platelets

(2) Conversion of prothrombin into active thrombin by the enzyme thromoboplastin (thrombokinase) in the presence of calcium ions

(3) Thrombin converts soluble blood protein fibrinogen into insoluble fibrin.

(4) Fibrin forms a network entangling the blood corpuseles this forming a clot.

## FACTORS INVOLVED IN BLOOD COAGULATION

According to International Commission on Blood coagulation (1954) following thirteen coagulation factors are involved in blood coagulation. The serial numbers of the factors should be written in Roman numericals.

**Factor**

I - Fibrinogen (synthesised in the liver)

II - Prothrombin (synthesized in the liver)

III - Thromboplastin (Thrombokinase) (enzyme released from injured blood platelets or injured tissue in mammals')

IV - Calcium ion.

V - Labile factor of proaccelerin (synthesized in the liver)

VI - Accelerin

VII - Stable factor or proconvertin (synthesized in the liver)

VIII - Antihaemophilic factor or AHF (synthesized in the liver)

IX - Christmas factor or plasma thromboplastin component (PTC) synthesized in the liver

X - Sturart - Power factor (synthesized in the liver).

XI - Plasma thromboplastin antecedent (PTA) (synthesized in the liver)

XII - Hageman factor or surface factor (activated when comes in contact with skin surface)

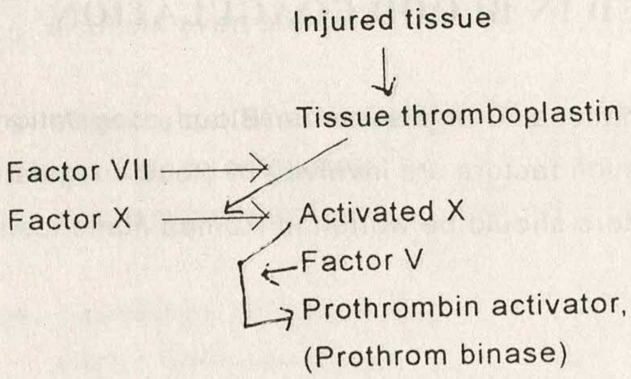
XIII - Fibrin stabilizing factor or Laki - Lovand factor (from blood platelets).

## b. Mechanism of blood coagulation

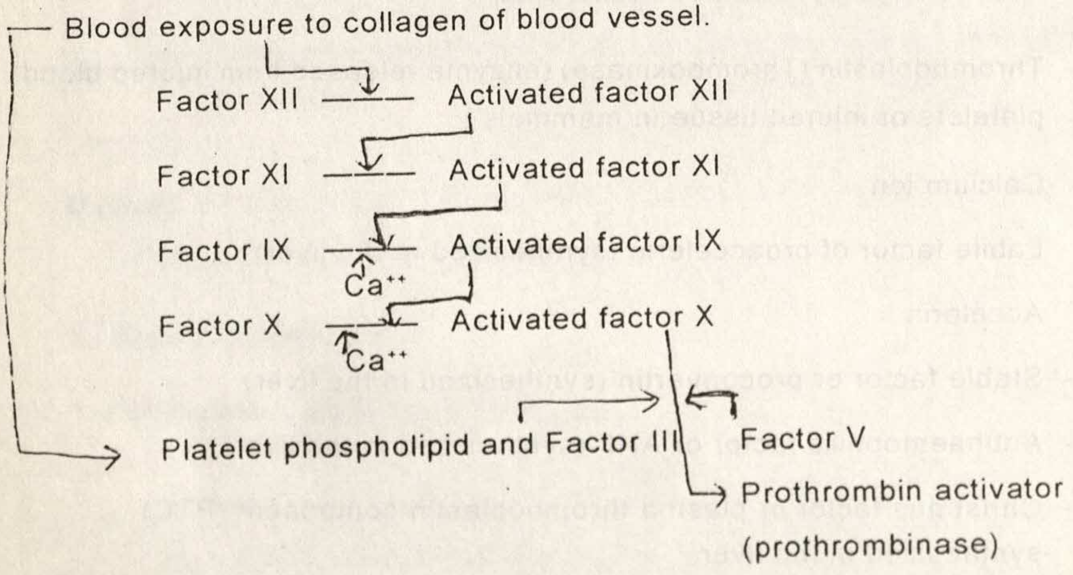
Blood clotting is a cascade mechanism which involves three essential steps

### (A) Formation of Prothrombin activators. This is formed in two ways

Extrinsic pathway



Intrinsic pathway



### (B) Conversion of prothrombin into thrombin

Extrinsic or intrinsic prothrombin activator (prothrombinase)

Hydrolysis

prothrombin ——→ thrombin

(A potein of blood plasma) $Ca^{++}$

### (C) Convertion of fibrinogen to fibrin

Thrombin

Fibrinogen ——→ Fibrin monomer (insoluble)
(soluble) (Factor XII)
in Plasma (Polymerization)
Fibrin thread

Fibrin threads form a network which entangles blood corpuseles, platelets and plasma to form a clot, so the process is called blood clotting. Within a few minutes, the clot begins to contract and a straw coloured fluid called serum is discharged. This is called clot retraction. Serum differs from blood plasma in being without blood clotting proteins like prothrombin, fibrinogen, hence it can not be clotted.

* **Anticoagulants** (A substance which prevents blood coagulation)

Heparin, Hirudin, warfarin, coumarin Sodium Oxalate, Sodium citrate, EDTA (Ethylene diamine tetra acetic acid), and chilling of blood.

Heparin - It is synthesized by mast cells of connective tissue and liver cells. It increases the effectivity of antithrombin III ($\alpha$ globulin) which prevents activities of prothrombin. So it prevents the conversion of fibrinogen into fibin. Moreover uninjured tissues or platelets do not release thromboplastins. Usually the blood circulating inside the blood vessels does not clot. (a) due to presence of heparin (b) non-formation of thrombin due to absence of thromboplastin.

## Role of vitamin K in blood clotting

Vitamin K is also called anti-hemorrhagic factor. This is a soluble vitamin and essential in the formation of prothrombin from the liver. Deficiency of vitamin K causes hypoprothrombinemia which interfere with blood clotting.

Diseases associated with defects in blood coagulation.

(a) **Hemophillia** - This is a recessive sex linked disease, which exclusively occurs in males in which blood does not clot. This is of three types :

Haemophillia - A - Caused due to deficiency of antihaemophillic factor (AHF) or factor VIII synthesized in the liver.

Haemophillia - B - Caused due to the deficiency of Christmas factor (PTC) or Factor IX

Haemophillia - C - Caused due to deficiency of PTA or Factor XI.

(b) **Thrombosis** - This involves the formation of blood clots called thrombos inside the blood vessels and blocks the blood flow.

(c) **Fibrinolysis** - This involves the dissolution of blood clot by an enzyme called plasmin.

## ∗ Methods of teaching

1) The topic should be well discussed in the class room with all reactions and formulae.

2) Charts may be used to show the reactions occuring in series.

### 4. Physiology of excretion

## * Probable Cause of Difficulty/Error

The concept is not well explained, leading to poor understanding by the students.

## * Explanation

Excretion is the process in which the nitrogenous waste substances produced during metabolisms separated and removed from the body. These substances are harmful, nitrogenous substances. They vary in different animals. In any animal, whether *Amoeba* or man, a fully balanced physio-chemical system is found in the protoplasm. The function of the excretory system is to keep this internal environment in a state of equilibrium. Water and carbon dioxide are formed as waste products in the body as a result of catabolism of carbohydrates and fats. Several kinds of waste substances are also formed, due to the catabolism of proteins. The main waste substance of excretory products are urea, uric acid, ammonia, amino acids, creatine and creatinine etc.

## * Classification of animals on the basis of excretory products

Animals are broadly classified into three groups based on the type of excretory products :

### 1. Ammonotelic animals

The animals which predominantly excrete ammonia are called *Ammonotelic animals* and the process of excretion of ammonia is called *Ammonotelism*. It is excreted by aquatic animals, because ammonia is freely soluble and rapidly diffusible through water. The Ammonotelic animals include protozoans, actinozoans, polychaetes, annellids, crustaceans, Aplysia, Sepia, Octopus, echinoderms, teleosts, and aquatic amphibians. Ammonotelism is very strictly determined by the availability of water.

### 2. Ureotelic animals

The animals predominantly excreting urea are called Ureotelic animals. The process of excretion of urea is called Ureotelism. Urea is formed from ammonia through ornithine cycle under protein metabolism.

As the urea is less toxic, the ureotelic animals can store urea in dilute solution in their blood. Elasmobranch (fish) can retain 2 to 2.5% urea in their blood. Mammals can retain 38mg/100ml of blood.

Urea is the excretory product of some semi-terrestrial animals, e.g., amphibians and mammals. In such animals, the availability of water is not plenty.

Amphibian tadpoles are ammonotelic. They excrete 40% of nitrogen as ammonia. After metamorphosis, ammonia excretion is reduced to 12.5% and urea excretion increases proportionately.

### 3. Uricotelic animals

Animals excreting uric acid are called uricotelic animals. The process of excretion of urea is called uricotelism. All terrestreial animals are uricotelic, e.g., insects, reptiles and birds.

Uric acid is insoluble in water. Hence, it does not require water for excretion. So uricotelism is exhibited by animals which require water conservation. It is essential for desert animals like insects, land snails, reptiles and birds and those which live in dry terrestrial habitat,

## * The process of urine formation

Urine is the excretory fluid eliminated by the kidney. Formation of urine is a highly sensitive and complex process. It involves the following steps.

1. Ultrafiltration.
2. Reabosorption.
3. Tubular secretion (synthesis of some new excretory substances)

## 1. Ultrafiltration

The first step in urine formation occurs at the malpighian corpuscle. The blood and the capsular space of the Bowman's capsule are separated by capillary endothelium and capsular epitheilium. Arterial blood flows in the glomerulus. This blood is filtered by the Bowman's capsule and enters into the capsular space. The fluid present in the capsular space is called glomerular filtrate.

The glomerular filtrate resembles a cell-free and high molecular protein-free blood. The constituents and glomerular filtrates are water, glucose, amino acid, $Na^+Cl^-HCl_5.PO^-$ ions along with urea and other excretory wastes.

The rate of blood flow in the glomerulus is 750 ml/ minute. From this, about 120 ml of blood is filtered as glomerular filtrate. In 24 hrs, 180 litres of glomerular filtrate is formed.

The filteration is facilitated by two factors -

(a) The capillaries of the glomerulus have very thin walls and the visceral epithelium of Bowman's capsule has tiny pores. The pores permit the entire blood to pass through, except the blood cells and proteins having molecular weights higher than 7000. Thus, glomerulus function as a mechanical filter.

(b) The driving force of moving fluid into Bowman's capsule is the net filtration pressure in the capillaries. The pressure in the glomerulus is +75 mm Hg because the afferent arteriole has larger diameter than the efferent arteriole. This force is opposed by the plasma protein osmotic pressure (about - 30 mm Hg) and the Bowman's capsular pressure of about 20 mm Hg. As a result, a net filtration pressure of about +25 mm Hg forces the blood to filter through the glomerulus. Therefore, fluid filters out of the glomerulus into the capsule. After entering the capsular space, the glomerular filtrate passes into the coiled portion of renal tubule.

## 2. Re-absorption

Every day, about 170 litres of glomerular filtrate is formed. But a normal man excretes only 1 to 1.5 litres of urine. More than 99% of the glomerular filtrate is re-absorbed into the blood by way of the capillary network enveloping the uriniferous tubule. The valuable and usable materials return to blood, but the wastes are retained in the tubule for excretion.

As the glomerular filtrate passes through the proximal convoluted tubule, approximately 80% of the water, sodium ions, chloride ions, most of the bicarbonates, all of the glucose, vitamins and amino acids are re-abosored into the surrounding network of capillaries.

Water re-absorption in proximal convolouted tubule occurs by osmosis, which is a passive and non-energy requiring process. But, the absorption of glucose, amino acid and vitamins is an active process, hence require energy (ATP) for this active transport.

In the loop of Henle, some water is absorbed in the descending limb, because, the osmotic gradient of medullary tissue surrounding it is higher. The ascending limb of loop of Henle is impervious to water, but pumps $Na^+$ ions actively inot the medullary tissue, thus raising its osmotic pressure.

In the distal convoluted tubule and collecting tubule, water is further re-absorbed under the influence of Antidiuretic hormone (ADH) secreted by the postererior lobe of pituitary. This hormone increases the permeability of the renal tubule and hence more water is reabsorbed. Under the influence of aldosterone hormone secreted by the adrenal cortex, $Na^+$ and $Cl^-$ ions are reabosrbed and $K^+$ and $H^+$ ions are excreted out.

## 3. Secretion by renal tubule

The concentration of certain substances in the urine is higher than that present in the glomerular filtrate. The urince also contains certain substances which are not present in the glomerular filtrate. It is clear that the renal tubule secretes some substances into the proximal convoluted tubule. $K^+$ and $H^+$ ions are secreted by the distal convoluted tubules. Creatinine and phosphates are other substances secreted. Substances such as penicillin, phenolsulphonaphthalein are also secreted. Reneal tubule synthesizes some substances such as $NH_3$, inorganic phosphate etc. and pours these into the nephric filtrate. $NH_3$ is formed to act as buffer when acidosis occurs.

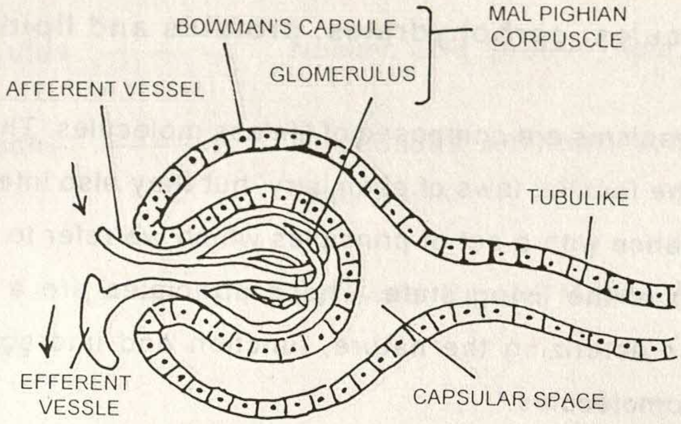


Fig. Malpighian corpuscle ( internal structure).

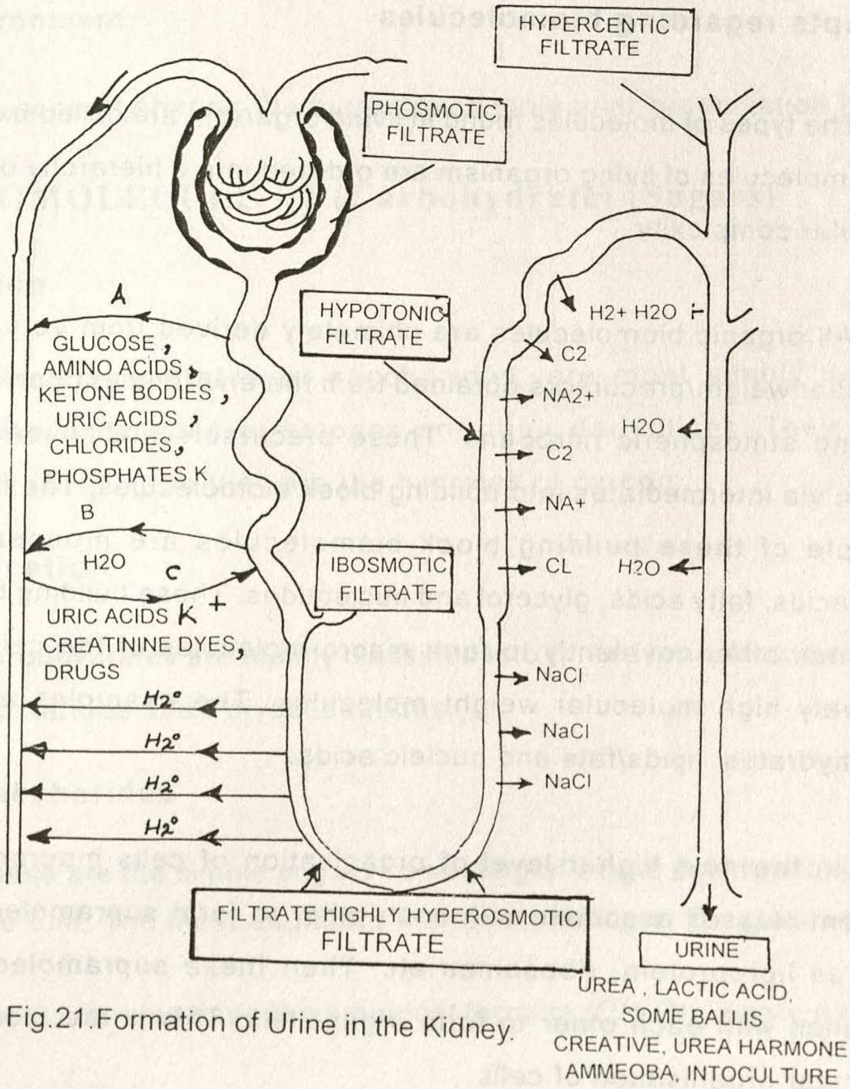


Fig.21.Formation of Urine in the Kidney.

## * Method of Teaching

By discussion method using appropriate chart, model and diagram.

## 5. Macromolecules: carbohydrates, proteins and lipids

Living organisms are composed of lifeless molecules. These molecules conform to all the familiar laws of chemistry, but they also interact with each other in accordance with a set of principles which we refer to collectively as molecular logic of the living state. These principles are a unique set of relationship characterizing the nature, function and interaction of certain "molecules - biomolecules."

### Concepts regarding biomolecules

The types of molecules found in living organism are called biomolecules. These molecules of living organism are ordered into a hierarchy of increasing molecular complexity.

All organic biomolecules are ultimately derived from very simple, low molecular weight/precursors obtained from the environment particularly $CO_2$, $H_2O$ and atmospheric nitrogens. These precursors are coverted by living system via intermediates into building block biomolecules. The five common example of these building block biomolecules are monosaccharides, aminoacids, fatty acids, glycerol and nucleotides. These building blocks linked with each other covalently to form macro molecules of the cells which are relatively high molecular weight molecules. The examples are proteins, carbohydrates, lipids/fats and nucleic acids.

In the next higher level of organisation of cells macromolecules of different classes associate with each other to form supramolecular system such as liproprotein, ribosomes etc. Then these supramolecular system combines with each other to form organellels. This is the hierarchy in the molecular organisation of cells.

**Organellels** ———→ The cell.

↑

**Supramolecular assemblies.** ———→ Ribosome enzyme complexes contractile system microtubules.

↑

**Macromolecules** ———→ Nucleic acid, protein, lipid, carbohy drate.

↑

**Building blocks** ———→ Nucleotides, Aminoacids, Monosaccharides, Fatty acids

↑

**Metabolic intermediates** ———→ Pyruvate, Citrate, Malate, Glyceralde 3 -$Po_4$.

↑

**Precursors from the environment.** ———→ $CO_2$, $H_2O$, $NH_3$, Nitrogen

(Flow chart sharing the hierarchy in molecular organisation of cell).

## MACROMOLECULE - 1 (Carbohydrate) (Sugars)

### Defination

The carbohydrates or saccharides, are most simply defined as polyhydroxy aldehydes or ketones and their derivatives. Their empirical formula is $(CH_2O)_n$, so they are the hydrates of carbon.

### Classification

Carbohydrates are mainly classified into three types. Monosaccharides, Oligosaccharides and Polysaccharides.

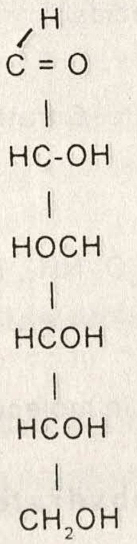
### Monosaccharides

These are the simple sugars consisting of single poly hydroxy aldehyde or ketone unit. The most abundant monosaccharide is D - glucose.

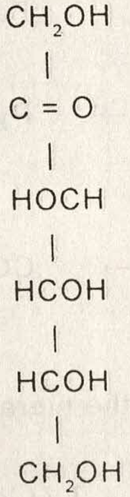
* Mnosaccharides have the empirical formula $(CH_2O)_n$, where n=3 or more.

- The carbon skeleton of the common monosaccharides is unbranched. Each carbon atom except one contains hydroxyl(OH) group. At the remaining carbon there is a carbonyl group.

- The carbonyl group if is aldehyde derivative the monosaccharides are called aldose. If it is ketone derivative, then the monosaccharide is called as ketone.



$$\begin{array}{c} \text{H} \\ \text{C}=\text{O} \\ | \\ \text{HC-OH} \\ | \\ \text{HOCH} \\ | \\ \text{HCOH} \\ | \\ \text{HCOH} \\ | \\ \text{CH}_2\text{OH} \end{array}$$

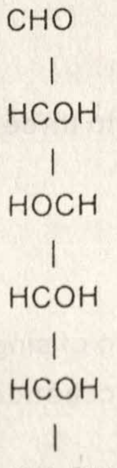


$$\begin{array}{c} \text{CH}_2\text{OH} \\ | \\ \text{C}=\text{O} \\ | \\ \text{HOCH} \\ | \\ \text{HCOH} \\ | \\ \text{HCOH} \\ | \\ \text{CH}_2\text{OH} \end{array}$$

(D - Fructose)

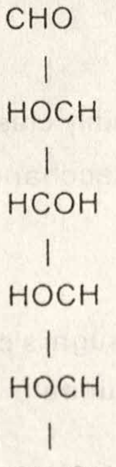
Glucose (aldose)

- Allmost all the monosaccharides contain one more asymmetric carbon atoms. Thus they show isomerism. As for example glucose is found in two different stereo isometric forms D glucose and L - glucose.



$$\begin{array}{c} \text{CHO} \\ | \\ \text{HCOH} \\ | \\ \text{HOCH} \\ | \\ \text{HCOH} \\ | \\ \text{HCOH} \\ | \\ \text{CH}_2\text{OH} \end{array}$$

(D - Glucose)



$$\begin{array}{c} \text{CHO} \\ | \\ \text{HOCH} \\ | \\ \text{HCOH} \\ | \\ \text{HOCH} \\ | \\ \text{HOCH} \\ | \\ \text{CH}_2\text{OH} \end{array}$$

(L - Glucose)

- The glucose and other sugars react internally to form cyclic hemiacetals. Hemiacetal formation is a characteristic reaction between aldehyde (c=0) and alcoholic groups of sugar. The hemiacetal form of D. Glucose shows a ring structure which occurs in two forms αD(+) glucose and BD(+) glucose depending on the hemiacetal carbon configuration.

## Disaccharides (oligo saccharides)

When a sugar compound contains two to ten number of monosaccharides it is called as a oligosaccharides. Most of the natural occurring oligosaccharides are disaccharides.

- The most common disaccharide are maltose, lactose and sucrose, cellubiose etc.

- Maltose is formed as an intermediate product of the action of amylases on starch containing two D glucose residues.

- Lactose is commonly called as milk sugar found in milk. It contains D galactose and D glucose.

- Sucrose is the cane sugar, is disaccharide of glucose and fructose. It is extremely abundant in the plant world and is familiar as a table sugar.

Cellobiose - It is a disaccharicle formed during the hydrolysis of cellulose.

## Polysaccharides -

- These are a group of sugars, on complete hydrolysis with acid or specific enzymes yeild monosaccharides and/or simple monosaccharides derivatives.

- Polysaccharides which are also called as glycan are divided into two types. Homopolysaccharides which contain only one type of monomeric unit, and heteropolysaccharides which contain two or more different monomeric units. The examples of homopolysaccharides are starch, and glycogen, where as the examples of heteropolysaccharides are hyaluronic acid, chondroitin etc.

- The polysaccharides found in nature either serve a structural function or play an important role as a stored form of energy. So according to their function they can be classified as storage or structural polysccharides. Starch and glycogen are common example of storage polysaccharides. Cellulose, chitin, chondroitin are the examples of structural polysaccharides.

## Sources of carbohydrates

Cereals such as wheat, rice, millets etc are rich source of carbohydrates. Cane-sugar, honey, Jaggary, roots and tubers alike potato, sweet potato are also chief sources of carbohydrates, Fruits like banana, sapota, mango are also rich sources of carbohydrates.

## Functions

(1) Carbohydrates serve as principal source of energy to the body. Each and every cell of our body is capable of obtaining energy from carbohydrates. The cells like brain cells, muscle cells mostly depend on carbohydrates in the form of glucose and glycogen. Glucose molecule can be completely oxidized to liberates its energy.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6H_2O + 6CO_2 + \text{Energy} \uparrow$$

(2) These are important food for storage because these are stored in the form of glycogen or starch in animal and plant cells.

(3) These group of macromolecules provide basic skeletal framework for both animal and plant cells.

## (Macromolecule - 2)

## Proteins

Protein are the most abundant organic molecules is cells constituting 50 percent or more of their dry weight.

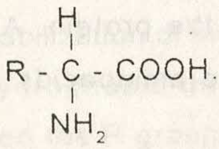
### (i) Defination

Proteins are defined as macromolecular polymers composed of aminoacids as the basic unit. The fundamental structural unit of proteins is the aminoacid. The proteins when hydrolyzed by chemical or enzymatic procedure, produce aminoacids.

### (ii) Structure of protein

### Structure of aminoacids

The general formula of an aminoacid can be represented as



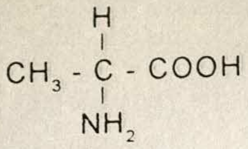
$$R-\underset{NH_2}{\overset{H}{C}}-COOH$$

The general formula shows that the aminoacids can be found in optical isomeric forms. But all the natural occurring aminoacids found in protein have the same configuration. There are all total 20 aminoacids found in nature.

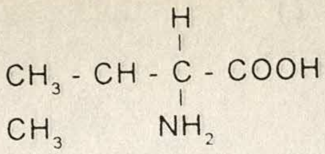
### (iii) Classification of aminoacids

Aminoacids are commonly classified into two groups.

(a) Aminoacids with hydrophobic R groups. The amino acids are alanine, valine, leucina, isoleucine methionine, phenylalanine, tryptophan. The structure of alanine and valine show the hydrophobic nature of R group.

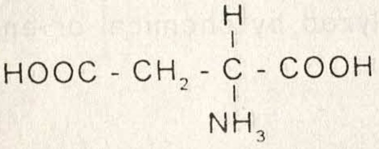

$CH_3 - \underset{NH_2}{\overset{H}{C}} - COOH$

L - Alanine

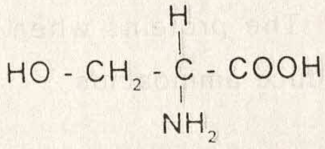

$\underset{CH_3}{CH_3} - CH - \underset{NH_2}{\overset{H}{C}} - COOH$

Valine

(b) Aminoacids with hydrophillic R Groups - The rest of the aminoacids are coming under this category. Examples are glycine, Serine, Threonine cysteine, Glutamin, tyrosine, Aspargine, Lysine, Arginine, Histidine, Aspartic acid, Glutamic acid etc.

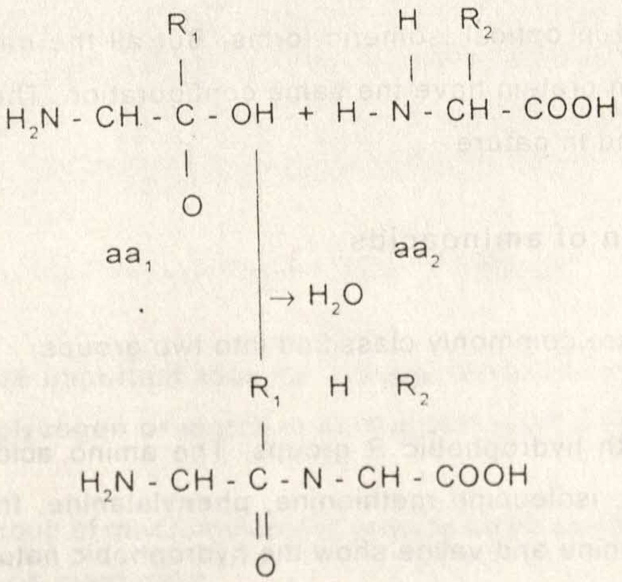

$HOOC - CH_2 - \underset{NH_3}{\overset{H}{C}} - COOH$

Aspartic acid


$HO - CH_2 - \underset{NH_2}{\overset{H}{C}} - COOH$

Serine

Structure of a Peptide - When two aminoacids link with each other through covalent bond, the resultant compound is called as a peptide and the bond is known as peptide linkage. Peptides are the intermediates in structural complexity between the aminoacids and the protein. A peptide containing two aminoacids is called dipeptide. three aminoacids is called tripeptides etc.


$H_2N - CH - \underset{O}{\overset{R_1}{C}} - OH + H - \overset{H}{N} - \overset{R_2}{CH} - COOH$

aa$_1$ aa$_2$

$\rightarrow H_2O$

$H_2N - CH - \underset{O}{\overset{R_1}{C}} - \overset{H}{N} - \overset{R_2}{CH} - COOH$

Dipeptide

## Protein structure

The proteins have four basic structural levels.

### (a) Primary structure

The primary structure of a protein is defined as the linear sequence of aminoacid residue making up its polypeptide chain. In this structure there is no other forces or bonds excepts peptide linkage.

### (b) Secondary structure

In the secondary structure of protein, besides peptide linkages there is hydrogen bond interaction between aminoacid residues fairly close to another in a primary structure.

### (c) Tertiary structure

This term refers to the tendency, of the polypeptide chain to undergo extensive coiling or folding to produce a complex, somewhat rigid structure. The stabilization of the structure is usually maintained by different interactions like hydrophobic interaction, disulfide linkage, hydrogen bonding etc in between the R groups.

### (d) Quaternary structure

This defines the structure resulting from interaction between separate polypeptide units of a protein containing more than one sub-unit.

## Classification of proteins

Protein can be classified into two major sorts - Fibrous protein and globular protein.

Fibrous proteins - The Protein in which the polypeptide chains are arranged in long strando or sheets are called fribrus protein. These are structural in function. Examples are keratin, Silk fibers, Collagen fibers, etc.

Globular proteins - The proteins, where polypeptide chains are tightly folded into a spherical or globular shape are called globular proteins. Examples are Haemoglobin, hormones, enzymes etc.

## Functions

(1) Protein are regulatory in function because of their role as enzymes and horomones. All the enzymes are protein in nature. A group of hormones called peptide hormones are protein in nature.

(2) Protein also used for storage like ovalbumin, casein, Ferritin etc.

(3) Protein also help in the transport of certain compounds for example

transports $O_2$ in blood of vertebrate - Haemoglobin
transport $O_2$ in blood of some invertebrate - Hemocyanic
transport $O_2$ in muscle cell - myoglobin
transport Fattyacid in blood - Serum albumin etc

(4) Some proteins are contractile in nature such as myosin, Actin of myofibrils. So they help in muscle contraction.

(5) Proteins have structural function like _ keratin, collagen, elastin etc.

(6) Certain proteins are protective in nature. Examples are antibodies, Fibrinogen, thrombin etc.

## Lipids (Macromolecule - 3)

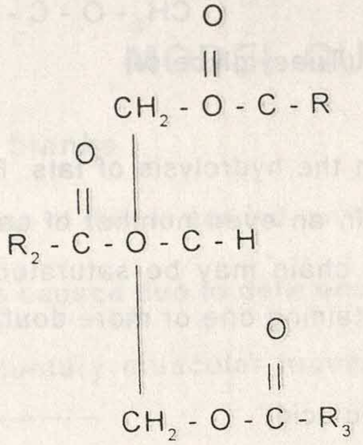
Lipids are another important group of macromolecules characterized by their sparing solubility in $H_2O$ and considerable solubility in organic solvent. It includes fats and fat like substances which are greasy in nature.

## Classification of lipids

Lipids are of three types - (1) Simple lipids
(2) Compound lipids
(3) Derived lipids.

## Simple lipids

Simple lipids are the easters of fattyacids with various alcohol molecules. For example fats which are easters of fattyacid with glycerol. A fat in liquid state is known as an oil.



Triacylycerol ( natural fat)

## Compound lipids

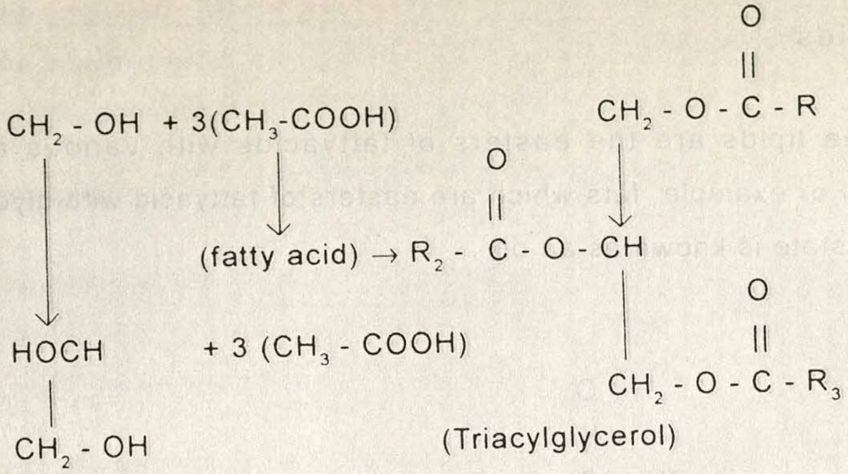
Compound lipids are also the esters of fattyacid and alcohol. But they contain one additional group like phosphate, sugar, aminoacids, nitrogenous base. Examples of compound lipids are phospholipids, glycolipids etc.

## Derived lipids

The substances derived from the above two group by the process of hydrolysis are called derived lipids. These include Fattyacids, Steroids etc.

## Fatty acids

Fatty acids are the building block of Fats. Three molecules of fatty acids attached to one alcohol (glycerol) forms one triacylglycerol.



(Triacylglycerol)

Fattyacids are obtained from the hydrolysis of fats. Fattyacids which occur in natural fats usually contain an even number of carbon atoms and are straight chain derivative. The chain may be saturated (containing no double bonds) or unsaturated (containing one or more double bonds).

$CH_3 - CH_2 - COOH$ (Propionic acid).
$CH_3 - (CH_2)_4$ COOH (Palmitic acid).
$CH_3 - (CH_2)_{22}$ COOH (Lignoceric acid).

**Structures of saturated fatty acid**

$CH_3 (CH_2)_7 CH = CH (CH_2)_7 COOH$ (Oleic acid).
$CH_3 - (CH_2)_4 (CH = CHCH_2)_2 (CH_2)_6 COOH$ (Linoleic acid).

**Structures of unsaturated fatty acid**

$CH_3 - CH_2 - COOH$ (Propionic acid).
$CH_3 - (CH_2)_4$ COOH (Palmitic acid).
$CH_3 - (CH_2)_{22}$ COOH (Lignoceric acid).

**Steroids**

The steroids are often found in association with fat. The examples of steroids are steroid hormones like male and female hormones, cholesterol etc.

**Functions of lipids**

(1) This is the major source of energy in animals and also high lipid containing seeds.

(2) They are used as storage materials (*food*) in the form of reserve food package.

## MODEL QUESTIONS

### 1. Fill in the blanks

a) Coagulation of milk is carried out by _____________ enzyme.

b) Beriberi is caused due to deficiency of _______________

c) The involuntary muscular movement of alimentary canal is called
_____________

d) Only _____________ vein carries oxygenated blood.

f) The valve present between the left auricle and left ventricle is called
_______________

g) Oxygen is mainly transported as __________ in the blood vessel.

h) The specific sites of respiration inside the lung, are _________

i) Glottis can be closed, during swallowing of food bolus, by
_____________

j) Ammonia is formed by the deamination of _____________

k) Blood enters the glomerulus through its _____________ arteriole and leaves the glomerulus through its _____________ venule.

### 2. Select the correct answer from the words within the bracket

a) Pepsin is an example of
(hormone, enzyme, vitamin, lipid)

b) Secretion of pancreatic juice is controlled by
(Secretin, cholecystokinin, enterokinase, enterogastrone)

c) Vitamins are
(Inorganic substances and cannot be synthesised by the animals, Inorganic substances that can be synthesized by animal, organic substances which can not mostly be synthesized by the animals. Organic substances which can mostly be synthesized by the animals.

d) Casein in milk is
(Carbohydrate, sugar, protein, fat)

e) End product of carbohydrate digestion are
(glucose, gulactose, fructose; sucrose, galactose, maltose; galactose, glucose, maltose; glucose, fructos, maltose)

f) A 2-layered sac surrounding the lung is
(pericardium, pleura, perichondrium, periosteum)

g) Air conditioning is done by
(Nasal chamber, nostrils, pharynx, alveoli)

h) Specially common in the alveoli of lung and villi of intestine of mammal is that which
(provide a large surface are, are hightly suited for diffusion of gases, have rich supply of blood vessels and lymphducts, have ciliated epitheliums)

i) When blood becomes acidic
($O_2$ carrying capacity of haemoglobin decrease, $O_2$ carrying capacity of haemoglobin increases, RBC count increases, none of these)

j) Contraction of sternohyal muscles during breathing in frog
(closes the glottis, raises the floor of the bucial cavity, lowers the floor of buccal cavity, opens the nostril)

k) In Rabbit air passes from outside into the lungs through (select the correct sequence)

(nasal cavity —>larynx —>pharynx —>trachea —>bronchi —>alveoli, nasal cavity —> larynx —>pharynx —>trachea —>bronchioles —> alveoli, nasal cavity —>pharynx —>larynx —> trachea —>bronchioles —>bronchi —>alveoli, nasal cavity —> Pharynx —>larynx —>trachea —> bronchi —>bronchioles —> alveoli)

l) Role of pacemaker is

(to increase heart beat, to decrease heart beat, to initiate heart beat, to control blood supply to heart)

m) Ultrafiltration occurs in glomerulus when

(hydrostatic pressure exceeds osmotic pressure, osmotic pressure exceeds hydrostatic pressure, capsular hydrostatic pressure exceeds glomerular hydrostatic pressure, colloidal osmotic pressure plus capsuler pressure remain less than glomerular hydrostatic pressure.

### 3. Short answer type
(Answer in Five sentences)

a) How urea is synthesized in the body ?

b) How a piece of meat is digested in the small intestine.

c) Why does a piece of bread tastes sweeter after chewed for sometime ?

d) What will happen if both the jaws of a frog are kept open for a long time ?

$d_2$) What is the role of Vitamin K in blood clotting ?

e) What is the role of haemoglobin in respiration ?

f) Why the gut epitheliums is not get digested ?

g) What are the functions of HCl in the alimentary canal.

h) What is carbon monoxide intoxication ?

i) Why herivorows animals posses longer alimentary canal as compared to carnivorous animal ?

j) What is the role of bile salts in the digestion and absorption of fats

k) Explain ornithine cycle.

(l) Make a chart showing the different blood groups with their respective agglutinogen and agglutinin.

m) What are the various functions of saliva in the mouth cavity of rabbit.

n) What are the diseases associated with blood clotting ?

o) Why does the left ventricle posses a thicker wall than the right venticle in Rabbit.

q) Explain the conducting system of the heart of rabbit.

**4. Long answer type**

1. How protein and fats are digested in the gastrointestinal tract of rabbit
2. What is the mechanism of formation of urine in the kidneys of mammals.
3. Explain the process of ventilation of lungs in rabbit with the help of diagrams. How gases are transported by the blood?
4. What are external and internal respiration ? How these are carried out in mammals.
5. How does the heart of a mammal function ?
6. What is a portal system ? What are the significance of the various portal systems in frog as well as rabbit ?
7. Compare the structure and function of the heart of frog and rabbit.
8. What is the nature of enzymes ? Enlist the functions of different digestive enzymes serially from mouth to the anus.
9. What are hormones ? Compare harmones with enzymes and vitamins.
10. what are proteins ? How does the structure of different types of proteins vary ?
11. Classify the carbohydrates. What are the role of each in the animal body.

12. Distinguish between

Proteolytic enzymes - Lipolytic enzymes.
Secondary proteins - Tertiary proteins.
Buccal respiration of frog - Pulmonany respiration of frog.
Vitamines - Enzymes.
$Co_2$ transport in blood - Co transport in blood.
Action of pancreatic juice. - Action of intestinal juice.
Absorption of fat - Absorption of aminoacids.
Cutaneaus respiration - Buccopharyngeal respiration.
Ultrafiltration - Selective reabsorption.
Conduction of heart beat in frog - Conduction of heart beat in rabbit
Monosaccharides - Polysaccharides.
Systole - Diastole.
Glycerol - Fatty acids
Simple lipid - Compound lipid
Fatty acid - Amino acid

13) What is a macromolecule ? Explain with examples.

14) What is the difference between monosaccharides and polysaccharides.

# VIII. ENVIRONMENTAL BIOLOGY

## 1. Energy flow in the ecosystem

### * Probable Cause of Difficulty/Error

1) Lack of understanding in the parts of students.
2) Concepts are not correctly explained in the class room.

### * Explanation

Energy is the capacity to do work. Biological activity requires utilisation of energy. Which ultimately comes from the Sun. Solar energy is transferred into chemical energy by the process of photosynthesis. This chemical energy moves from green plants to animals and man. Then the chemical energy gets transformed into mechanical and heat forms during metabolic activities.

### * Sun as the Source of Energy

The sun releases energy by the nuclear transmutation in the form of electromagnetic waves. Only one fifty-millionth of the Sun's energy output reaches the earth's outer atmosphere at a constant rate referred to as the solar flux. At a given place it varies diurnally because of the earth's rotation on its axis. It varies seasonally with latitude because of the earth's revolution around the Sun. About 42% of the solar flux is reflected back and about 10% is absorbed or diffusely scattered by atmospheric gases like ozone, oxygene, water, vapour, etc. Thus about 48% of the total solar flux actually reaches the earth's surface. Of this 48% a considerable amount in reflected back from light surface and bright sand. The radiant energy absorbed in the trophosphere, is radiated outward in the infrared portion of the spectrum. which is received by the soil, water, atmosphere and organisms on the earth's surface. This radiation heats up the earth and affects the climate and physiological process like photosynthesis, metabolism, growth, reproduction and other activities of organisms involving energy transformations and heat production.

## * Laws Governing Energy Transformation

Energy transformation in ecosystems can be explained in relation to the laws of thermodynamics. The first law is the law of conservation of energy which tells that energy is neither created nor destroyed but can only be transformed from one form to other.

The law recognises the interconvertibility of all forms of energy but does not refer to the efficiency of transformation. In ecological systems solar energy is converted into chemical energy stored in food materials and then into mechanical or heat energy. Hence energy is not created or destroyed in ecological systems but is converted from one form into another. The second law of thermodynamics states that processes involving energy transformation will not occur spontaneously unless there is degradation of energy from a non-random to a random form.

## * Energy Flow in the Ecosystem

Radiant energy coming from the Sun falls on plants. About 95 to 99 percent of this energy is lost from the green plants (autotrophs) in the form of heat of evaporation and sensible heat. The remaining 1 to 5 % is used in photosynthesis for primary production. This is stored as chemical energy.

On consumption the chemical energy along with nutrients pass from green plants to herbivores and from here in as heat and also as chemical energy with faecal matters. The rest is utilised in growth and reproduction or stored as chemical energy in their body.

From this again it passes to carnivores on consumption. In carnivorous organisms energy is utilised in growth, reproduction and storage. Some amount passes out with faecal matter. The energy flow is non-cyclic and it flows from Sun to decomposers. This has been shown in the figure below.

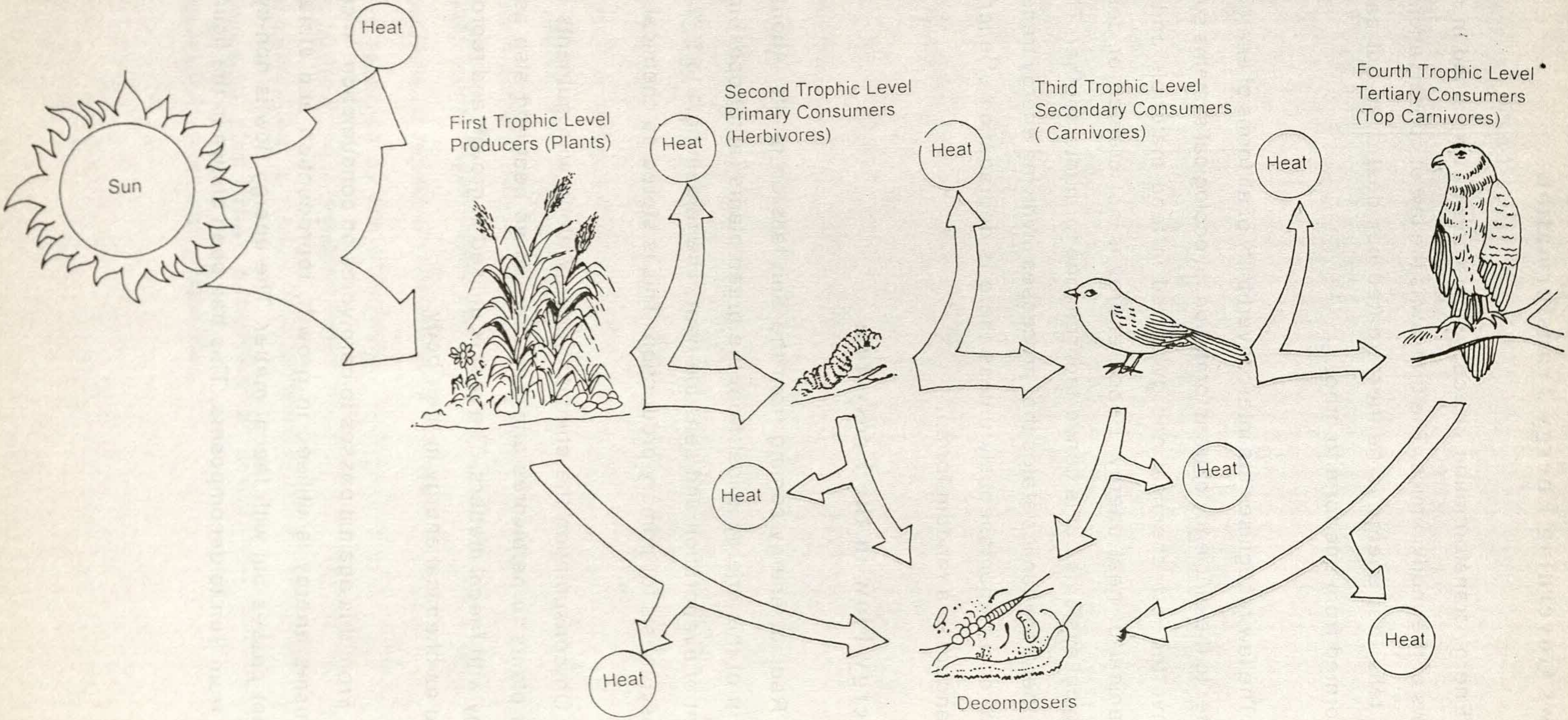


Fig.22 Energy flow in the Ecosystem.

The flow diagram shows that at each transfer, heat energy dissipates. Hence the energy transfer is not 100 percent efficient and there is degradation of energy from a non-random to a random form (second law of thermodynamics). Each transfer and the end result confirms the first law of thermodynamics.

## Methods of Teaching

The energy flow concept should be carefully taught using chart & diagrams so as to help the students in understanding it. Discussion method of teaching may be followed. While teaching importance of bio-energy may be highlighted.

## 2. Food chain & Food web

### * Probable Cause of Difficulty/Error

The difficulty may be due to lack of adequate discussion with suitable examples in the classroom.

### * Explanation

Autotrophs convert solar energy into chemical energy stored in food material. The transfer of food energy from plant sources through a series of organisms forms what is called a food chain. A diatom may be eaten by a copepod which is eaten by a small fish, which forms the food source of large fish and so on.

This can be shown as such -

**Phytoplankton → Zooplankton → Small fish → large fish → man**

It is a food chain that is commonly observed in an Indian river or lake. The following is an example of a food chain that occurs in an Indian Pasture.

**Grass Species ——→ Grasshoppers ——→ Toad ——→ Snake.**

In a forest ecosystem, the plants are eaten by deer which in turn is eaten by tiger.

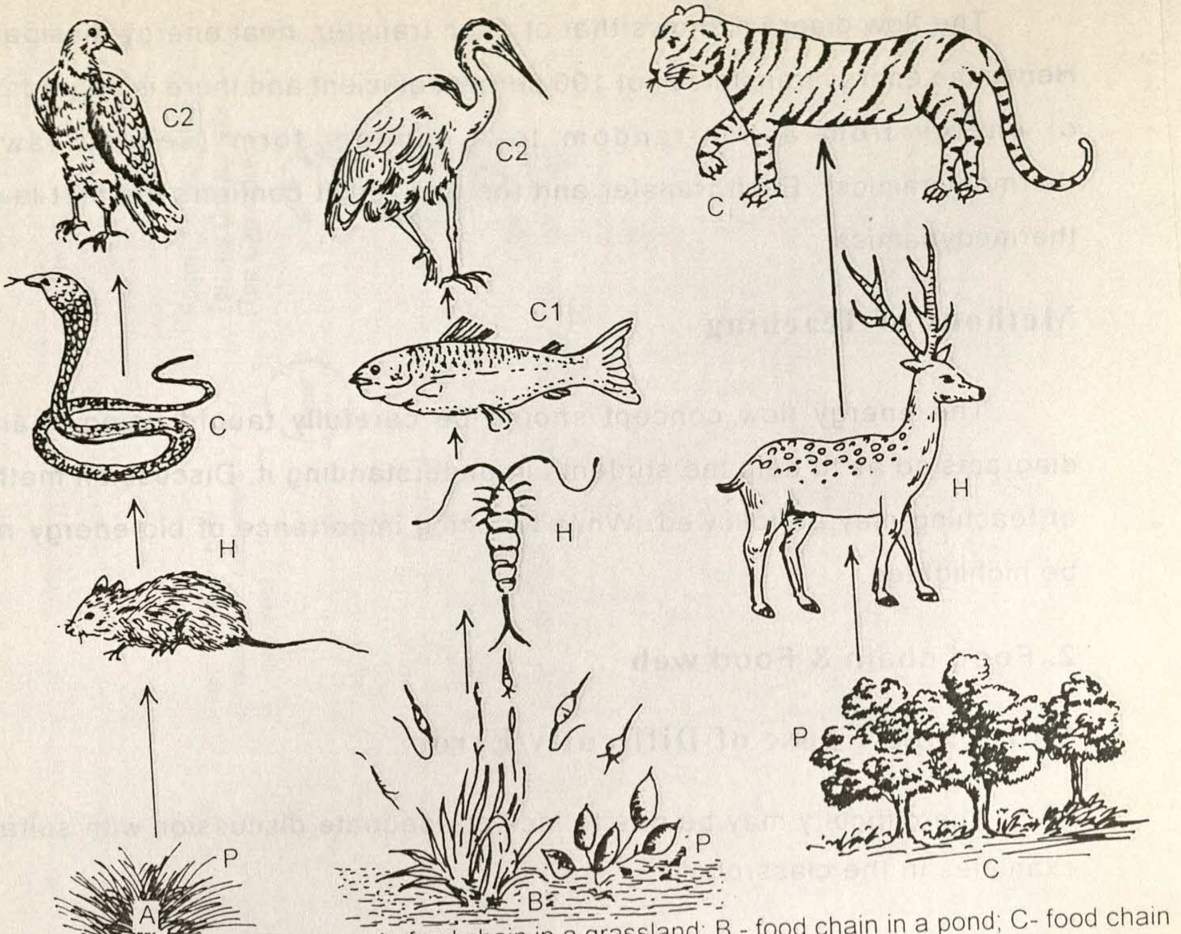


Fig.23 Food chains in nature A -food chain in a grassland; B - food chain in a pond; C- food chain in a forest. The base of the food chain is always formed by autotrophs (producers). The links are usually 3 to 5 and the arrangements is mainly ; producer- herbivore - carnivore. ( P - producer, H - herbivore, C1 -carnivore order - 1, C2 - carnivore order - 2)

In all the examples we find that the base of the food chain is always formed by a plant which is grazed on by a herbivore which is preyed over by a carnivore that may be eaten by another carnivore. The arrangement is always as such :

**Plant ——→ Herbivore ——→ Carnivore**$_1$ **——→ Carnivore**$_2$

In nature, food chain relationships are very complex, as one organism may form the food source of many organisms and so on. For example, grass may be grazed by grasshoppers as well as rabbits or cattle and these herbivores may be eaten by many carnivores, such as toads, snakes, birds, hyenas depending on their food habits. Thus instead of a simple food chain, a web like structure is always found in nature called as food web.

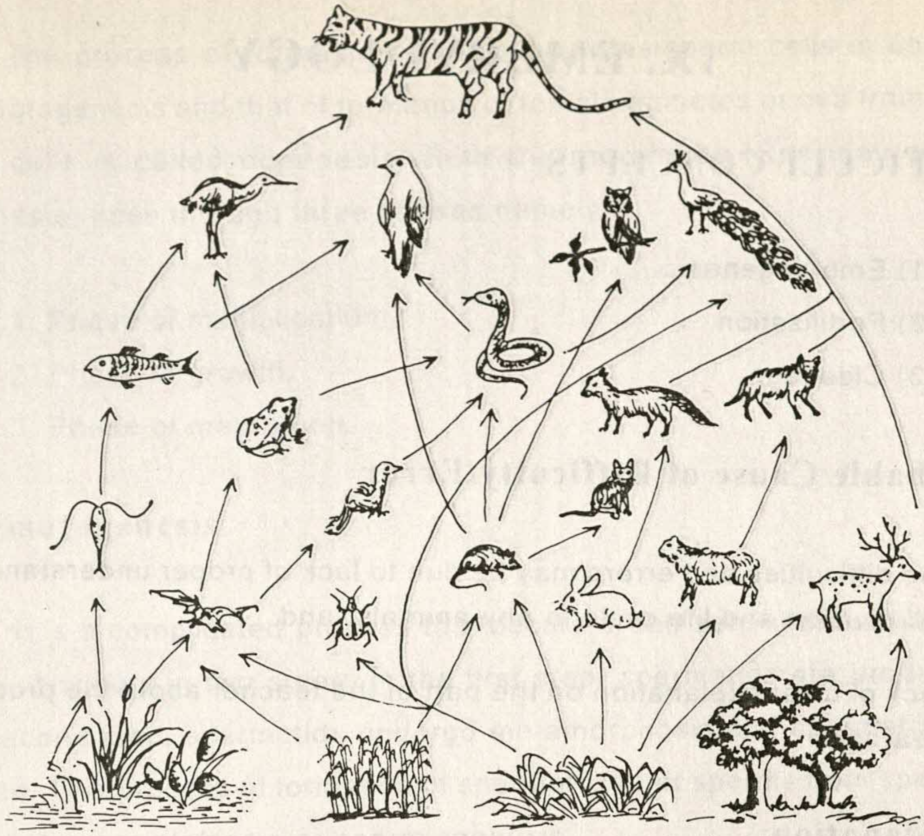


Fig.24 A food web shows the main food links and interconnection of many food chains. An organism may form a food source for many other organisms thus forming a web.

Organisms whose food is obtained from plants by the same number of steps are said to belong to the same trophic level. Thus green plants occupy the first trophic level, called the producer level and plant grazers occupy the second trophic level, called the primary consumer or herbivore level (insects, rabbits, deer, cattle). Flesh eaters which eat herbivores form the third trophic level, called the secondary consumer or carnivore level (frogs, small fish). The next trophic level is the tertiary consumer or carnivore which eat the flesh of herbivores and the secondary comsumers. Likewise the trophic levels can be expanded taking the food habits of organisms into account. It has been found that in a food chain very rarely the number of links exceeds because in the process of energy transfer there is always loss of energy to the environment in the form of heat.

# IX. EMBRYOLOGY

## * DIFFICULT CONCEPTS

(1) Embryogenasis.

(2) Fertilization.

(3) Cleavage.

## * Probable Cause of Difficulty/Error

(1) The difficulties and errors may be due to lack of proper understanding of cell division and life cycle in any animals. and

(2) Lack of clear explanation on the part of the teacher about the process of clearage.

## * Explanation

### 1. Gametogenesis

Two special types of cells called gametes take part in sexual reproduction. These cells are formed in gonards. Male gonards or testes form male gametes or sperms and female gonards. or ovaries form female gametes or ova. Gametogenesis is the process by which female and male sex cell or gametes (ova/sperm) are formed in the ovaries a testes respectively.

Reduction in the number of chromosomes to half is very essential in gametes because we know that the zygote is formed by the union of male and female gametes in sexual reproduction. Thus the number of chromosomes becomes normal in zygote. If reduction division does not take place, the nuclear of chromosomes would become double in zygote. Since every species has a fixed number of chromosomes it is necessary that the number of chromosomes in gametes is half that of the parents.

The process of formation of male gametes/sperm cells is known as spermatogenesis and that of formation of female gametes or ova from female germ cells is called oogenesis. Both the processes (Spermatogenesis/ oogenasis) pass through three phases namely

1. Phase of multiplication.
2. Phase of growth.
3. Phase of maturation.

## Spermatogenesis

It is a complicated process that occurs in the seminiferous tubules of testis. It occurs in two steps. In the first step, spermatids are produced. In the second step, spermatids undergo metamorphosis and spermatozoa are formed. This process of formation of spermatozoa or sperms from spermatids is called *spermatoleosis or spermiogenesis*.

## I. Formation of Spermatids

The spermatids are produced from the primary germ cells or primordial germ cells of the testis and occurs in three phases.

### 1. Multiplication Phase

The testes are composed of seminiferous tubules which are lined with germinal epithelium. Some of these cells become differentiated as primary germ cells or primordial germ cells while others function as the nutritive cells (e.g., Sertoli cells in mammal). They become comparatively larger in size with a prominent nucleus. During the phase of multiplication the primordial germ cells divide mitotically and produce a large number of cells called spermatogonia. Each spermatogonium represents a diploid cell containing 2X number of chromosomes.

### 2. Growth Phase

In this phase the spermatogonia increase in size by absorbing nutrients from other germinal cells. These enlarged cells are known as primary spermatocytes. These cells become ready to undergo maturation division or reduction division.

### 3. Maturation Phase

It is a very important phase. Primary spermatocytes divide twice. The first division is meiotic and two haploid cells are formed which are known as secondary spermatocytes. The second division is mitotic type and no further change occurs in the chromosome number. Thus from two secondaryspematocytes four spematids are formed. In other words, each primary spermatocyte gives rise to four spermatids.

## II. Spermatoleosis or Spermiogenesis

The spermatids formed as a result of maturation division is a typical cell containing mitochondria, golgi body and centriole, but with one haploid set of chromosomes. It undergoes gradual differentiation to form a motile sperm, the process being known as spermatoleosis. The changes involve reduction of weight by losing superfluous material and development of such structures that help in movement.

### Structure of Sperm

A typical spermatozoon is small, thread like and motile. It consists of three parts : (1) head
(2) middle piece and
(3) tail.

1. Head - The head contains the nucleus. In the anterior part, the protoplasm bulges out forming the acrosome i.e. formed by Golgi bodies.

2. Middle piece - It is present between head and tail as a small piece. It contains the centrioles and a few mitochondria.

3. Tail - It is present behind the middle piece. It consists of an axial filament enclosed in protoplasmic heath. The last part of the tail which is naked is called end piece.

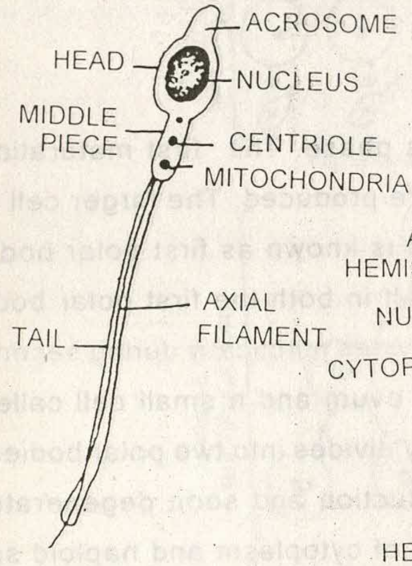


Fig. Structure of a sperm

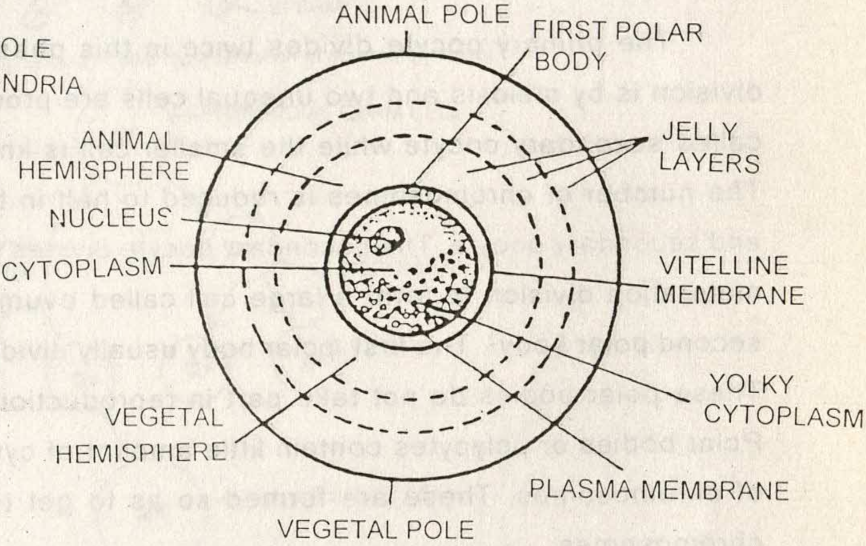


Fig.25. Structure of an ovum (unfertilised) of frog.

## (B) Oogenesis

It is a process by which ova are formed from the primary germ cells of the ovary. It is divided into three phases :

1. Multiplication Phase
2. Growth Phase
3. Maturation Phase

### 1. Multiplication Phase

The first phase is similar to that of spermatogenesis. The cells of the germinal epithelium divide repeatedly by mitosis to produce many oogonia or egg mother cells. Each oogonium is diploid. It ceases to divide before entering into the next phase.

### 2. Growth Phase

In this phase each oogonium increases in size due to accumulation of yolk and nutritive substances. The cell is now called primary oocyte. The growth phase is prolonged and may vary from few days to two or more years.

### 3. Maturation Phase

The primary oocyte divides twice in this phase. The first maturation division is by meiosis and two unequal cells are produced. The larger cell is called secondary oocyte while the smaller cell is known as first polar body. The number of chromosomes is reduced to half in both the first polar body and secondary oocyte. The secondary oocyte divides mitotically during second maturation division to form a large cell called ovum and a small cell called second polar body[2]. The first polar body usually divides into two polar bodies. These polar bodies do not take part in reproduction and soon degenerate. Polar bodies or polycytes contain little amount of cytoplasm and haploid set of chromosomes. These are formed so as to get rid of excess number of chromosomes.

Thus it is clear that during spermatogenesis, the primary spermatocyte produces four spermatozoa whereas in oogensis only one ovum is produced from the primary oocyte.

## Structure of Ovum

The mature ovum is a spherical or oval non-motile cell. The ovum of hen is about 30mm. in diameter, wheras that of frog is only 2mm. The human ovum is as small as 0.15mm. The ovum usually contains variable amount of yolk to nourish the future embryo.

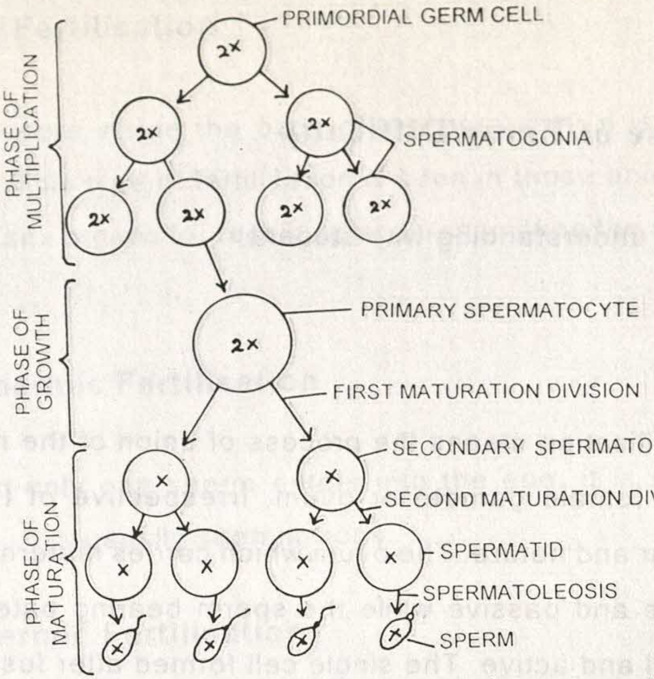


Fig. Diagrammatic representation of spermatogenesis.

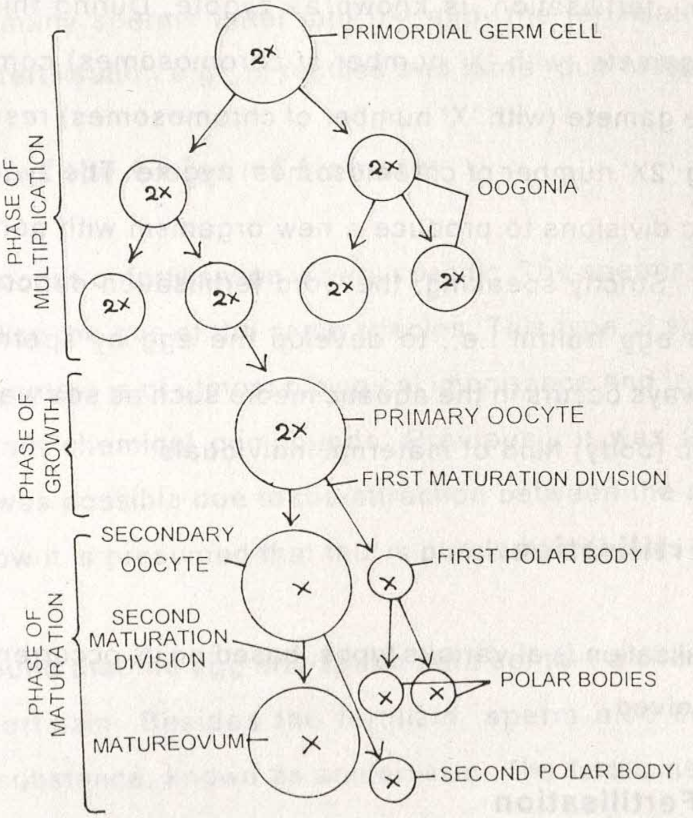


Fig.26. **Diagrammatic representation of oogenesis.**

## 3. Fertilization

### * Probable Cause of Error/Difficulty

Lack of clear understanding with student.

### * Explanation

The term fertilisation means the process of union of the male gamete or sperm with the female gamete or ovum, irrespective of their relative structure, behaviour and nature. The ovum which carries maternal hereditary information is large and passive while the sperm bearing paternal genetic information is small and active. The single cell formed after fusion of ovum and sperm i.e., fertilisation, is known as zygote. During this process, the haploid male gamete (with 'X' number of chromosomes) combines with the haploid female gamete (with 'X' number of chromosomes) resulting to form a diploid (having '2X' number of chromosomes) zygote. The zygote under goes several mitotic divisions to produce a new organism with normal (2x) set of chromosomes. Strictly speaking, the word fertilisation denotes the process of making the egg fruitful i.e., to develop the egg by sperm contact. The fertilisation always occurs in the aquatic media such as sea water, fresh water or intrasomatic (body) fluid of maternal individuals.

### Kinds of Fertilisation

The fertilisation is of various types, based on its occurrence and number of sperms involved.

#### 1. External Fertilisation

If the fertilisation occurs outside the body of the organism, it is known as external fertilisation e.g. in frog.

### 2. Internal Fertilisation

If it occurs inside the body of the organism, it is termed as internal fertilisation. This type of fertilisation is seen in those animals which possess specialised sex organs for receiving and transmitting the sperms e.g. in rabbit and man.

### 3. Monospermic Fertilisation

When only one sperm enters into the egg. it is called monospermic fertilisation. It is usually seen in frogs.

### 4. Polyspermic Fertilisation

When many sperms enter into the egg, the fertilisation is known as polyspermic fertilisation e.g., in reptiles and birds (due to large yolky eggs).

## Specificity of the Union of Gametes

The process of fertilisation is very specific. The sperms of one particular species fertilise the ova of the same species. This type of specificity of male and female gamets is of utmost biological importance and is achieved by the help of certain chemical compounds. Previously it was thought that the fertilisation was possible due to the attraction between the male and female gametes. Now it is presumed that this is purely accidental.

It is found that the egg and sperm both contain a chemical substance, known as fertilizin. Besides the fertilizin, sperm also contains another proteinous substance, known as antifertilizin. The fertilizins of the eggs are supposed to attract the sperms which contain a particular type of antifertilizin. It has also been found that the egg fertilizin of any species reacts efficiently with the sperm antifertilizin of the same species.

## Process of Fertilisation

The process of fertilisation includes two major successive steps such as :

1. Activation of the egg.
2. Amphimixis of fusion of gametonuclei.

### 1. Activation of the Egg

The process of activation of egg is completed in the following stages.

#### (i) Movement of the Sperms towards the Egg

Fertilisation always takes place in a fluid medium. The sperms swim towards the egg at random and collide with the egg by chance. The fertilizin and antifertilizin become active after the chance collision of the sperms with the ova. The egg fertilizin usually occurs in the jelly surrounding the egg. It gradually dissolves in the surrounding water of the egg and forms the so-called egg water.

#### (ii) Penetration of Sperm into the Ovum

It is accomplished by the (a) activation of sperms and (b) the activation of egg and insemination.

(a) Activation of sperms : When a sperm with a specific antifertilizin comes in contact with the egg water of its own species then certain significant changes occur in the acrosome of the sperm. The peripheral portion of acrosome of the sperm collapses and its enzymes, the lysins are released out and dissolved in the water. The central portion of the acrosome elongates in order to form a long, thin and rigid tube known as acrosomal filament. When the sperm acquires such acrosomal filament, it is said to be activated and becomes ready for penetration in the unfertilized egg. When the activated sperms reach the egg, the acrosomalfilaments penetrate into the egg jelly and vitelline membrane by the help of dissolving action of the lysin enzyme. As soon as the tip of the acrosomal filament touches the egg membrane, various important morphological and physiological changes occur in the egg fertilization of an egg by a sperm. (1) Contact of sperm with the ovum. (2) Penetration path and copulation path of the sperm nucleus in the egg during fertilisation. (3) Fusion of nuclei of sperm and ovum.

(b) Activation of egg and insemination : When acrosomal filament touches the egg surface, the cytoplasm of the egg bulges out to form a cone like process known as fertilisation cone at the point of contact. The fertilisation cone engulfs the sperm and the sperm moves inwards. Only the head and middle piece of the sperm enter but not the tail. The entry of the sperm into the egg is known as the *insemination*. Just after the insemination, a *fertilisation membrane* is formed around the plasma membrane of the egg which prevents the entry of further sperms. The route through which the sperm moves into the cytoplasm of egg is known as *penetration path*. Then the sperm changes its direction in order to reach female pronucleus. This changed route is known as copulation path. On entry of the sperm, the egg completes the second maturation division and gives off second polar body. Under vitelline membrane the first polar body is also seen.

## 2. Amphimikis

Now the nucleus of sperm is known as male pronucleus and the nucleus of egg is known as female pronucleus. After extrusion of second polar body the female pronucleus approaches the male pronucleus. The sperm rotates in such a way so that the middle piece containing centrosome and mitochondria remains in between male and female pronuclei. Now the haploid number of chromosomes appear in each pronucleus and nuclear membranes of both the pronuclei breakdown. Then centrosome divides into two, forming asters around each centriole. The maternal and paternal chromosomes now become arranged around the equator of the spindle. In this way, the diploid number of chromosomes is restored, forming a zygote nucleus. This spindle represents the first cleavage spindle. The zygote now becomes ready for cleavage and formation of the embryo.

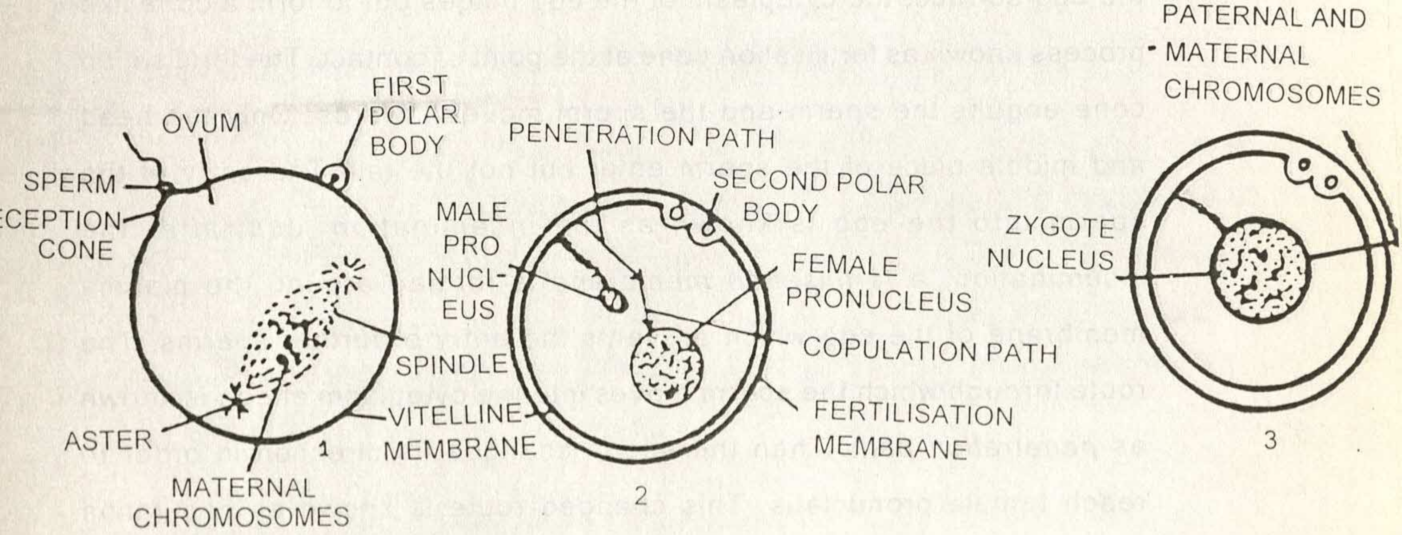


Fig. 27. Schematic figures showing process and events in the fertilisation.

## Importance of Fertilisation

1. The egg is activated by the entry of sperm and gets stimulus to undergo second maturation division releasing second polar body.

2. As a result of fertilisation, the zygote is formed in which the diploid number of chromosomes is restored.

3. During centriole introduced into the egg, by the sperm. This centriole is absent in the mature egg and it initiates the division of nucleus of zygote.

4. The entry of sperm brings about the formation of fertilisation membrane which prevents further entry of sperms.

5. Fertlisation provides new genetic constitution and variation in individuals and this is due to mixing of chromosomes of two gametes because the zygote containing maternal and paternal chromosomes develops into new organism.

6. It enhances the metabolic activities and the rate of protein synthesis of the cell and establishes definite polarity in the egg.

## 3. Cleavage

### * Cause of Difficulty

The concepts are not well explained in the class room. Teaching aids/ models are not used while explaining the concept.

### * Explanation

Cleavage occurs soon after the fertilization or activation of the egg. The fertilized egg or zygote is a single cell. It must be converted into a multicellular body having sufficient number of cells. In the zygote this is achieved by the series of rapid mitotic cell divisions until many cells are produced. The division of zygote by a series of mitotic cell divisions to form a multitude of cells which become the building units of the future organism is called segmentation or cleavage. The resultant cells of the cleavage are called blastomeres and the end product of cleavage is called a blastula.

## Characteristics of Cleavage

The cleavage of eggs in all animals have some common characteristics.

1. All divisions are rapid and take place rapidly one after the other. But their rate depends upon the concerned species and temperature.

2. During the cleavage, there is no growth in the resulting blastomeres and the overall size and volume of the embryo remain the same. The zygote is a relatively large cell and as a result of successive divisions, the size of the blastomere is gradually reduced to that of the ordinary body cells. However, in the ordinary mitotic division of body cells, each division if followed by a period of growth of daughter cells before the latter divide again.

3. In the zygote, the volume of the cytoplasm is proportionately greater than that of the nucleus and therefore nucleo-cytoplasmic ratio is very low. During cleavage the size of the blastomeres decrease progressively but the nuclear size remains the same. As a result, the nuclear cytoplasmic ratio increases and finally becomes the same as in the ordinary cell.

4. During cleavage, the blastomeres do not move and therefore the general shape of the embryo does not change except for the formation of a cavity in the interior.

5. Early cleavage divisions occur synchronously, i.e., all the blastomeres divide simultaneously. But this synchrony disappears after a few dozen of blastomeres have been formed.

6. For rapid nuclear division, there is an increase in the synthesis of DNA needed for the duplication of chromosomes.

7. The consumption of oxygen is greatly increased during cleavage.

During cleavage the division furrows do not occur in a haphazard direction but are oriented in a regular manner with reference to the animal vegetal axis or polar cells of the egg. This orientation of cleavage furrows is not the same in all species. Therefore various patterns of cleavage are found amongst animals. The following three types are particularly common.

1. **Radial** - The radial cleavage occurs when the successive cleavage planes cut straight through one another and the resultant blastomeres are placed in a radially symmetrical manner around the animal - vegetal axis (Sponges, Coelenterates and some Echinoderms).

2. **Bilateral** - This cleavage pattern arises when the first three division planes do not stand at right angles to each other. In this pattern the radial symmetry is lost and the blastomeres are so arranged that the right and left side become apparent (Vertebrates, Cephalopods, few Molluscs and some Echinoderms).

3. **Spiral cleavage** - The spiral cleavage results due to oblique positions of mitotic spindles in the blastomeres and is also called oblique cleavage. In this cleavage the blastomeres are arranged in a spiral manner around the animal vegetal axis (Flat worms, Annelids and most Molluscs).

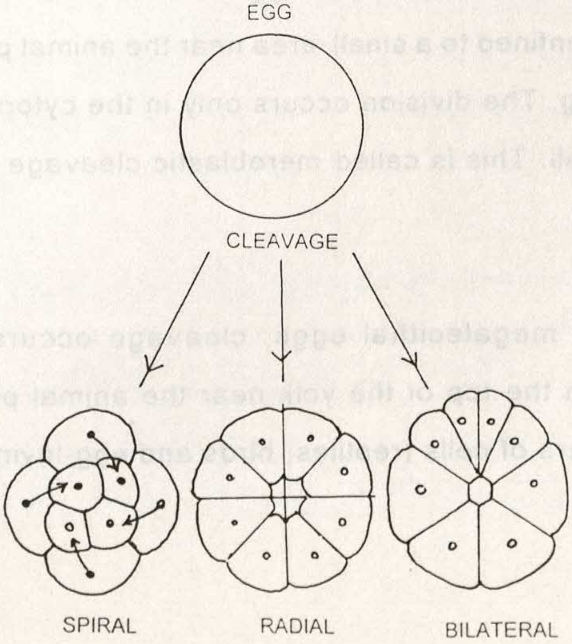


Fig.28.Figures showing spiral, radical and bilateral patterns of cleavage in animal eggs.

## Types of Cleavage

Cleavage is influenced by the quantity of yolk and its pattern of distribution in the egg. This is because the yolk is an inert substance and retards the progress of furrow to divide the cytoplasm. Accordingly the following types of cleavage are found in animals.

### 1. Holoblastic Cleavage

When the furrow divides the egg or blastomeres completely, it is called holoblastic cleavage. It is (a) equal if the resulting blastomeres are of equal size as it happens in most microlecithal or isolecithal type of eggs or (b) unequal if the daughter blastomeres are unequal in size. This is seen in the case of telolecithal eggs of frog and some fishes in which the third cleavage produces four small and four large blastomeres. The smaller balstomeres are called micromeres and the larger ones, macromeres or magameres.

### 2. Meroblastic Cleavage

In the polylecithal or macrolecithal eggs with enormous quantities of yolk, the cytoplasm is confined to a small area near the animal pole or around the periphery of the egg. The division occurs only in the cytoplasm and the yolk is not affected at all. This is called meroblastic cleavage and is of two types.

(a) Discoidal - In the megalecithal eggs, cleavage occurs only in the cytoplasmic cap on the top of the yolk near the animal pole forming a disc of several layers of cells (reptiles, birds and egg-laying mammals).

(b) Superficial - In the centrolecithal type of eggs of insects, at first the nucleus located in the centre of yolk divides repeatedly. The daughter nuclei then migrate to the peripheral cytoplasm which subsequently divides into many cells, each with a nucleus.

Towards the end of the cleavage the rate of cell division slows down and blastula is formed. The types of blastula vary a great deal amongst animals depending upon the size of eggs the amount and distribution pattern of yolk and the pattern of cleavage.

# X. ECONOMIC ZOOLOGY

## DIFFICULT CONCEPT

### 1) Immunity

### * Probable Cause of Difficulty Error

(i) Lack of clear discussion in the class room

(ii) The topic is not adequately covered in the text.

### * Explanation

### Immunity

It is the ability of an organism to resist the development of a disease, if it is said to be immune. The immune system of the body is responsible for development of immunity.

Immune system is a system which can differentiate between 'self' (body's own cells) and 'nonself' (Foreign microbes). An antigen is a foreign substance which when enters the body is capable of stimulating an immune response. The protective chemicals produced by the body in response to antigen are known as antibodies. Antibodies are proteins called immunoglobulins (Igs). Antibodies are always antigen specific i.e. each kind of antigen stimulates the formation of specific antibody.

Lymphocytes are kind of agranuloctes of leucocyte (WBC) of blood. These form the main cells involved in the immune system of the body. These are formed by liver and thymus in the foetus and by the bone marrow and lymph nodes in adults. There are two kinds of lymphocytes; T-lymphocytes and B-lymphocytes. T-lymphocytes are formed in the thymus and B-lymphocytes differentiate especially in the bursa of Fabricus, a mass of lymphoid tissue near the cloaca in most vertebrates, but in mammals in lymphoid tissues of tonsils, peyer's patches and appendix

### Differences between B-lymphocytes and T-lymphocytes

| B-lymphocytes | T-lymphocytes |
|---|---|
| 1. B-lymphocytes produce antibodies which act against the antigen (Humoral system) | 1. T-lymphocytes directly attack the pathogenic micro-organism that have entered the host's body or protects the body from its own cells cancerous (cell-mediated immune system) |
| 2. These act against viruses and bacteria that enter the blood and the lymph Do not react against transplants and cancerous cells. | 2. These act against pathogenic microorganisms, organ transplantations, cancerous cells, allografts etc. |
| 3. These produce group of plasma cells which produce antibodies, Plasma cells do not move to the site of infection. | 3. These produce alone of T cells. T cells are of three types - killer, helper and supressur cells. T cells directly attack pathogens. |

## Types of Immunity : Immunity is of two types

### A. Inborn or Innate or Natural immunity.

It is present from the birth and is inherited from the mother to offsprings through placenta. It is not acquired from the previous attack of the diseases.

**B. Acquired or adoptive immunity**

It is not present from the birth but is developed by the organism in response to disease caused by the infection of microbes causing diseases or vaccines.

(2) Parasitism,
(3) Host - parasite relationship and
(4) Pathogenicity

## * Probable Causes or Difficulty

(i) May be due to lack of proper discussion in the class room.

## * Explanation

**Parasitism :** It is a type of association between two organisms in which smaller partner, called 'parasite', desires food and shelter from in or on the body of larger partner called 'host' and inhibits the survival of host population. Parasitism is found throughout the animal kingdom but is mostly found among the protozoans, flatworms, nematodes and arthropods. The parasites can not survive without their hosts.

Depending on the basis of host-parasite relationship parasitism is of two types.

**(a) Temporary or partial parasitism -**

In this only or part of life cycle of parasite is spent as parasite. Eg. - Glochidium lawa underyaing metamorphosis on a fresh water fish.

**(b) permanent parasitism -**

In this, the organisms spend their whole life cycle as parasites. It is again of two types.

**Ectoparitism -**

In this, the parasite lives outside the host's body. e.g. bags, fleas, ticks, lice, leaches, numerous crustaceans (socculina on crab), few vertelbrates. (petromyzon or larger fish, a shark by sucking action of its buccal funnel, makes a hole in the host's body with its rasping and foolied tongue, mixes the anticoagulant and sucks the blood).

**Endoparasitism -**

In this, the parasites live inside the body of the host. e.g. Talnia, Ascaris and Entamoles in the intensive of man, plasmomedium in the liver cells and RBCs of man, Wuchereria in the lymph vessels of man, Try panosoma in the cerebrospinal fluid of man etc.

Some animals shaw both ectoparasitic as well as endoparasitic phases and there are remarkable differences in the morphology of these two phases e.g. socculina.

Some organisms become parasitic only when in association with the host while otherwise lead a free life. These are called facultative parasites. e.g. Oyster prawn. Some organisms pead only parasitic life and are host specific. These are called obligatory paronites e.g. flat worms, tape worms. Sometimes a parasitic is further parasitized by another parasite and the phenomenon is called hyperparasitison e.g. Nosema notabilis on sphae respora polymarpha which in turn is a parasite of urinary bladder of food fish.

Holoparasites depend fully on the host for nutrition. Semiparasites derive only water and minerals (a part of their nutrition) from the host. Majority of parasites are micro organisms.

In social parasitism one species is exploited by another species for some benefit e.g. Cuckoo lays its eggs in the nest of crow.

**Host parasite relationship -**

Host parasite interaction includes the effects of the parasite upon the host and the effects of the host upon the parasite.

**Influence of the relationship -**

It has been shown by experiments that the initial host density determines the emergence of the parasite and it is the number of the parasite that fixes the final density of the host. Some other experiments show that rise and fall in population of parasite is relative to increase and decrease in population of the host. Sometimes fluctuation of these may occur.

The parasites and hosts would be able to maintain dynamic equilibrium, provided the host population is high and the rate of parasitisation is also high.

Environmental factors also influence the relationship.

Host density effects the rate of increase of parasite. If the density of the host is higher the rate of parasitisation is also high. But sometimes the increase in host population brings about a fall in the parasites eg. wasp Heterospilus prosopides parasitising the larvae of azuki been weevil Callosofructius clenensis.

Intraspecific competition between the parasites of the some host population also exists in which ectoparasites may bring about the fall of host population but after that the endoparasites survive more.

In the case of different species of endoparasites effecting the common host, the two parasites enter into an interaction commonly called as antagonism or antagonistic interactions. Antagonism may be direct like predation or mechanical injury or may be indirect causing retardation of development.

When a host is attacked by tow or more species of parasites more than once, the relationship is called super - parasitism.

If the parasites are over carded, the size of the individual parasite decreases and in certain cases degenerate forms result because, of overcrowding and consequent insufficiency of food

**Pathogenicity Parasites are of two types.**

Non pathogenic - The nonpathogenic parasites have no noticeable ill - effects on the host. For example Entamoeba coli, Trichomones hominis, Endolimax nana etc.

Pathogenic : The pathogenic parasites are those which case ill-effects or diseases to the hosts. parasites reach the new hosts by active migration, direct transfer, accidental infection, infection by intermediate host or congenial transfer. The ill effects are called pathogenecity of the parasite.

# XI. APPROACHES TO BIOLOGY TEACHING

## - Few words.

Teaching is an interactive process. In this process, the teacher, the learner and the instructional material interact with each other. The nature of Biology needs various kinds of activities so that the learners get opportunities to have meaningful experiences. In these situation, teaching methods play an important role. The methods encourage and reinforce learning.

There are various kinds of teaching methods from which a biology teacher can select and use. Various methods commonly practised by the classroom teacher are lecture method, discussion method, Demonstration method, project method, problem solving method, inquiry method, group Teaching method etc. of which lecture method is considered as the simplest. Detail discussion about each method is beyond the scope of this chapter. The selection and use of a method depends on the objectives of the lesson/ topic, needs of the learners and the facilities available. The teacher should select a method where student can involve themselves, develop the power of inquiry and enjoy their learning.

As far as possible, the teacher should well plan his/her teaching works, and theory classes should start from practicals. In outdoor classes such as during collection of specimens/plant materials the teacher should encourage group or team work.

In theory., especially large size classes teaching aids, and multi media package should be used to make teaching effective, Looking to location (urban/rural) of schools/junior colleges. Local specimens/materials should be used in the classes to make learning relevant and meaningful .The students should be encouraged to ask questions to help improving their inquisitiveness besides learning life skills. However the success of teaching in classroom/ field depends on the interest and commitment of the teacher who happens to be a friend, philosopher and guide for the student.

# XII. REFERENCES

1. Mishra D., C.S. Sarangi and L.K. Mohapatra (1997) Higher Secondary (+2) Botany, Vidyapuri, Orissa.

2. Nanda, A.K. (1997) Text Book of Botany, Kitab Mahal, Orissa.

3. Salisbury, F.B. and C.W.Ross (1986) Plant Physiology, CBS Publishers and Distributors, Delhi.

4. Noggle, G.R. and G.J. Fritz (1986) Introductory plant physiology, Prentice Hall India, New-Delhi.

5. Bewley, J.D. and M.Black (1982) Physiology and Biochemistry of seed Vol.II. Springer Verlag, New York.

6. Lehninger, A.L. (1984) Principles of Biochemistry CBS Publisher and Distributors.

7. Salisbury, F.B. and C.W. Ross (1974) Plant physiology, CBS Publisher and Distributors, New Delhi.

8. RIE (1997) Analysis of common errors in Biology Committed by students at the Plus Two Science Examination conducted by CHSE, Orissa, 35p.

9. Sood, J.K (1987) Teaching Life Sciences - A book of methods Kohli Publishers - 253P.

10. UNESCO (1980) Biology Education in Asia and the Pacific UNESCO Regional Office, Bangkok, PP 3-17.

11. Bendre, A and Pande, PC. (1997) Introductory Botany. Rastogi Publications. 901 P.

12. Jeffery, C.(1968) Introduction to Plant Taxonomy London

13. Jeffery, C. (1977) Biological nomenclatures, London,

14. Baijal, H.N. and M.K. Ray (1996) Modern +2 Zoology, Arun Prakashan, Gwalior (M.P)

15. Morphology of Angisperms - by Venkateswarlu.

16. An introduction to plant Taxonomy - by Jeffery, C. (1968) London

17. Biological nomenclator - by Jeffery, C. (1977) London.

# LIST INTERNAL RESOURCES PERSONS

1. Prof. A.L.N. Sharma.
   Head, Dept. of Science
   RIE, Bhubaneswar.

2. Dr. M.P. Sinha
   Reader in Botany
   RIE, Bhubaneswar.

3. Dr. U.K. Nanda
   Reader in Zoology
   RIE, Bhubaneswar.

4. Dr. M.K. Satapathy
   Reader in Botany and
   Prog. Coordinator.

5. Dr. D.G. Rao
   Sr. Lecturer in Zoology
   RIE, Bhubaneswar.

6. Mrs. D. Dash
   Sr. Lecturer in Zoology
   RIE, Bhubaneswar.

7. Dr. P.K. Pattanaik
   Sr. Lecturer in Zoology
   RIE, Bhubaneswar.

# LIST EXTERNAL RESOURCES PERSONS

### Botany

1. Dr. B. Pradhan
Reader in Botany
Revenshaw College,
cuttack.

2. Dr.(Mrs.) Devaki Pradhan
Reader in Botany
N.C. College, Jaipur

3. Dr. N.K. Sen
Reader in Botany
Rajdhani College,
Bhubaneswar

4. Mr.K.B. Mohanty
Lect. in Botany,
S.G. College, Jaipur.

5. Dr. B.N. Mishra
Lect. in Botany
G.M. College, Sambalpur

6. Dr. M. Pradhan
Reader in Botany
J.K.B.K. College,
Cuttack.

7. Dr. A.K. Dalai
Reader in Botany
Revenshaw College
Cuttack.

8. Dr. B.C. Acharya
Reader in Botany
S.D. Women's College
Rourkela 769003

### Zoology

1. Dr. R.K. Mohanty
Reader in Zoology.
Rajdhani College,
Bhubaneswar

2. Dr. Sandhya Das
Reader in Zoology
Revenshaw College,
Cuttack

3. Dr. N.B.K. Choudhury
Secretary, Orissa,
Bigyan Academy,
Bhubaneswar

4. Dr. A.K. Mohanty
Reader in Zoology
S.C.S. College, Puri.

5. Dr.(Mrs) J. Mohanty
Reader in Zoology
Revenshaw College,
Cuttack

6. Dr. S.N. Ghosh
Reader in Zoology
G.M. College,
Sambalpur.

# LIST OF REVIEWERS

1. Prof. B.P. Choudhury
Dept.of Botany
Utkal University
Bhubaneswar.

2. Prof. R.C. Mohanty
Dept. of Botany
Utkal University,
Bhubaneswar.

3 Prof. M. Kar
Dept. of Botany
Utkal University,
Bhubaneswar.

4. Prof. (Miss) K. Bohidar
Dept. of Zoology
Utkal University,
Bhubaneswar

5. Dr. S.K. Dutta
Reader in Zoology
Utkal University,
Bhubaneswar.

I.C.Z.R.
Library
Calcutta
25/3, B. C. Roa